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ABSTRACT

Investigations in Natural Science is a program in secondary school biology, chemistry, and physics based upon the description of science as a quest for knowledge, not the knowledge itself. This teaching guide is designed for use with the 18 biology investigations found in the student manual. These investigations focus on concepts related to: organisms; classification; populations; producers; food chains; ecosystem; cells; cell transport; circulation; calories; digestion; breathing; responses; locomotion; cell division; reproduction; inheritance; and homeostasis. Each investigation includes activities related to the three learning cycle components, namely, exploration, conceptual invention (the idea), and expansion of the idea. The guide contains: (1) a list of biology concepts fostered in each investigation; (2) detailed instructional strategies for the student investigations, which are reproduced in the teacher's manual in reduced form; and (3) student reading questions and answers (the readings, however, appear only in the student manual). Included in appendices are student materials and teaching guide on microscope skills, sample essay evaluation questions for each investigation, and a list of equipment and materials needed for each investigation. (JN)

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INVESTIGATIONS IN NATURAL SCIENCE

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BIOLOGY

Teacher's Guide

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FOREWORD

Investigations in Natural Science is a program in secondary school biology, chemistry and physics based upon the description of science which says, "Science is the quest for knowledge, not the knowledge itself."[*] That description of science is harmonious with that given by Einstein: "The object of all science is to coordinate our experiences and bring them into a logical system."[**] Notice that Einstein describes science as bringing our experiences into a system and does not describe science as the *resulting system*. Einstein's *developing a system* and Roller's *quest for knowledge* are describing the same thing; science is the search and the developing.

We asked ourselves what should students search or quest for in the three disciplines, and the obvious answer seemed to be understanding of the concepts of the disciples. In order to state the concepts we believed students would develop during a quest, a detailed study was made of the intellectual capabilities of the students who enroll in the courses. Those findings were used in stating concepts which are given in each of the three courses. [illegible] determining the intellectual capabilities of the students, the quality-of-thought model of Jean Piaget was used for guidance. In using that model, the recent modifications made in it by persons other than Piaget were considered.

An investigation to be conducted by the students which would lead them to each concept was prepared. These investigations--eighteen in biology, eighteen in chemistry and thirty-six in physics--constitute what the students study in those three courses. A basic axiom of teaching was used in constructing the investigations. That axiom is: *One person cannot teach another unless the teacher understands a model of how the learner learns*. The learning model used was the *mental functioning* design of Jean Piaget. That model states that through interacting with the phenomenon (or concept) to be learned--and its associated materials--students *assimilate* the essence of the concept and that assimilation causes them to wonder, or puts the students in *disequilibrium*. The nature of a disequilibrated state leads students to re-equilibriate themselves by *accommodating* their mental structures and thinking processes to the assimilation. In essence, students put their thoughts in accord with those things which give rise to the assimilation. The new thought--says Piaget's mental functioning model--now must be *organized* with pre-existing thoughts and ideas, or thought must be put in accord with thought. In this way, the students *construct* their own knowledge of the concept investigated. These new constructs incorporate both the processes of science as well as its content and become a part of the students' mental structures rather than just a short-term set of memorized facts about the concept.

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[*] Duane Roller, "Has Science a Climate?" *Sunday Oklahoman*, Oklahoma City, Okla., February 22, 1970, p. 23.

[**] V. H. Booth, *Physical Science*, New York, N.Y.: MacMillan Publishing Co., 1962, p. 51.

The mental functioning model was used as the model of learning upon which the teaching plan in the Investigations in Natural Science was based. The assimilation experiences are provided by a series of activities under the heading Exploration. In those activities, the students gather data which they and the teacher use to arrive at an accommodation which is the concept to be learned. That accommodation begins in the exploration but reaches fruition in a section entitled Conceptual Invention or The Idea. Organization experiences are included in a section called Expansion of the Idea. Each investigation includes a rich and sometimes a long expansion section. Teachers must use their judgment in deciding whether or not all the activities in each expansion will be used. We feel that the students may not always complete an entire Expansion section.

One part of the Expansion section of nearly every investigation which we believe is imperative is the student readings. Students read about a concept after they have experienced it in those programs. That is truly and expansion-of-the-idea activity. Reading about a concept before experiencing it--the advanced reading assignment--causes students to read about something they do not understand and that often leads to attempting to remember rather than understand what was read. The placement of the readings was carefully planned and we believe those readings serve their purpose. Teachers are urged to discuss the readings with their students; that discussion is essential to the Expansion-of-the-Idea phase of each investigation.

The three-phase teaching plan and curriculum organization procedure used in constructing the investigation in all three disciplines--Exploration, Conceptual Invention (The Idea) and Expansion of the Idea--is know as the learning cycle. We cannot take credit for inventing the learning cycle; that credit goes to Dr. Robert Karplus, University of California, Berkeley, The Science Curriculum Improvement Study and, of course, Dr. Jean Piaget.

Norman, Oklahoma

October, 1984

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ABOUT THE AUTHORS. . . . .

The authors of the INVESTIGATIONS IN NATURAL SCIENCE: BIOLOGY program have two common places of employment--the Norman, Oklahoma, Public Schools and the University of Oklahoma. Those authors also have a second common characteristic; they are all knowledgeable about the Piagetian developmental-learning model and are interested in using it as a curriculum-construction model and a classroom-teaching procedure model.

John W. Renner is a Professor of Science Education and Adjunct Professor of Physics at the University of Oklahoma and Edmund A. Marek is an Assistant Professor of Science Education at that institution. Larry Atkinson and Carl Surber are biology teachers in the Norman Public Schools as was Jean Cate when the project started; she is now the system's science coordinator. Eileen Grzybowski teaches biology and chemistry.

BIOLOGY CONCEPTS

Investigation	Concept
1. Organism	1. An organism has certain characteristics that distinguish it from a nonliving thing.
2. Classification	2. Observable characteristics of organisms allow them to be classified.
3. Population	3. A population is a group of organisms of the same species affected by environmental variables in the habitat.
4. Producers	4. Green plants use light to make their own food and are known as producers.
5. Food Chain	5. Food energy is passed from producers through a series of consumers, forming a food chain.
6. Ecosystem	6. Interacting populations and environmental variables form an ecosystem.
7. Cells	7. Organisms are composed of cells.
8. Cell Transport	8. Some materials pass into or out of the cell and other material do not.
9. Circulation	9. Blood is pumped throughout an animal by the action of the heart.
10. Calories	10. Foods produce heat energy.
11. Digestion	11. Foods must be digested to pass into or out of the cell.
12. Breathing	12. Animals exchange gases with the environment.
13. Responses	13. Animals receive stimuli from the environment.
14. Locomotion	14. Muscles and bones enable some animals to move.
15. Cell Division	15. New cells are produced by the process of mitosis.
16. Reproduction	16. Some organisms develop from fertilized eggs.
17. Inheritance	17. Observable characteristics are passed from parents to their offspring.
18. Homeostasis	18. Organisms are capable of adjusting to changes in the environment.

INVESTIGATION #1: ORGANISMS

EXPLORATION

Grab Bag

Many Things

CONCEPTUAL INVENTION (THE IDEA)

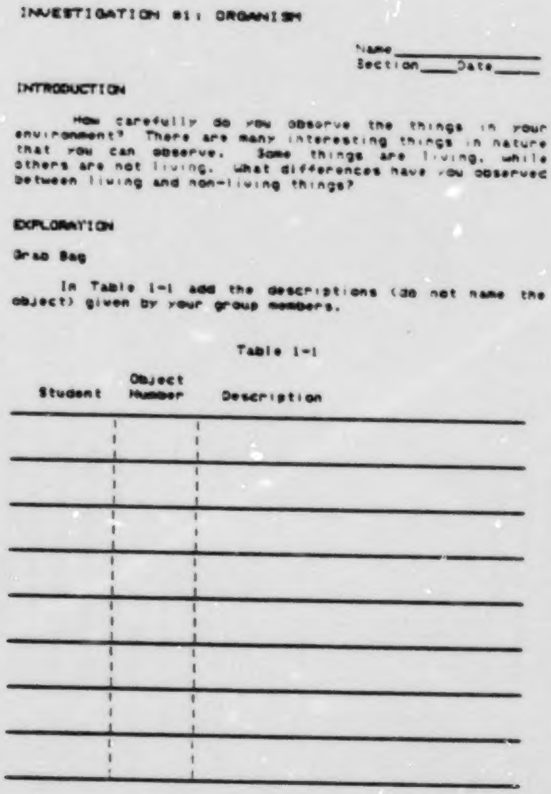
An organism has certain charcteristics that distinguish it from a non-living thing.

EXPANSION OF THE IDEA

Cold Water

Reading: Supplying the Needs

Optional: Worm Tracks



INVESTIGATION #1: ORGANISM

Name________________
Section____Date____

INTRODUCTION

How carefully do you observe the things in your environment? There are many interesting things in nature that you can observe. Some things are living, while others are not living. What differences have you observed between living and non-living things?

EXPLORATION

Grab Bag

In Table 1-1 add the descriptions (do not name the object) given by your group members.

Table 1-1

Student	Object Number	Description

Pass out page 1-1 to each student (you may wish to provide several copies of page 1-1 to the student). Prepare enough sacks so that each group of students has several small paper sacks, each containing a different object. One at a time, the students reach into one of the bags placed on their desk and carefully feel the object. Students should not look into the bag. As the student feels the object inside the bag, the student describes the object so that the other members of the group can record the description. The teacher moves from group to group listening and asking the students about the size, shape, texture, weight, temperature, or movement of the object.

Have the students exchange the bags within the groups to see if another group member can add to the description and record additional descriptions to Table 1-1. In addition to using sight and touch in direct observation, ask students to state two ways in which each group could improve their observations.

During class discussion, have each group share their observations with the class. You might ask someone to make a drawing on the board from the descriptions given or let other groups guess what object is being described.

Class discussion might include the following questions:

What else might have been included in the description? (Bring out using other senses, taking more time, comparing them to known objects, keeping in mind size, shape, and texture, using other instruments, increasing accuracy.)

What drawings could you make from the description? (To make drawings, a thorough description is necessary.)

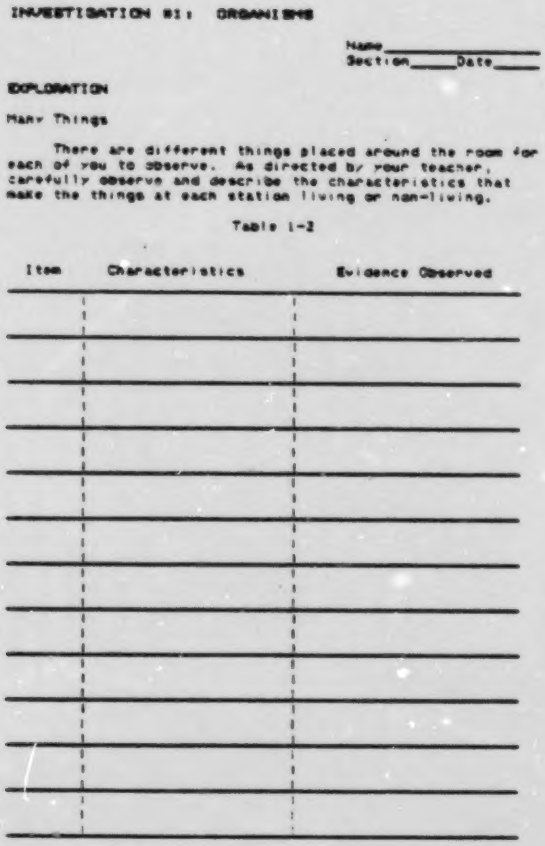
What does the word "observe" mean? Name some synonyms for "observe." (To look at or examine closely; examine, look at, study.)

What senses other than touch and sight do we use for making observations? (Smell, taste, hear.)

What tools do scientists use to aid them in observing? In what ways do these tools help? (Microscope, telescope; enlarge small objects, allow us to see things far away.)

What career persons depend upon powers of observation? (Doctors, police, medical technicians, restaurant personnel, geologists.)

To conclude the discussion have each group share their observations with the class, letting other groups guess what object is being described. The students should open their bags to see what the objects look like, adding any observations from using their sight.



INVESTIGATION #1: ORGANISMS

Name________________
Section_____Date_____

EXPLORATION

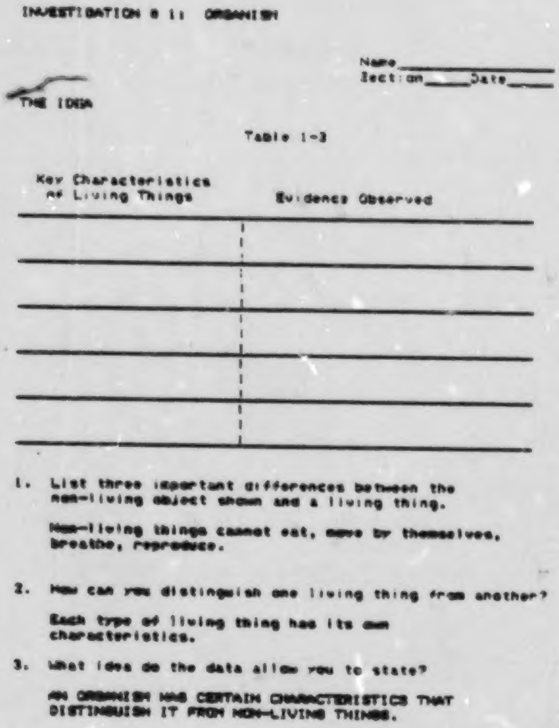
Many Things

There are different things placed around the room for each of you to observe. As directed by your teacher, carefully observe and describe the characteristics that make the things at each station living or non-living.

Table 1-2

Item	Characteristics	Evidence Observed

In addition to some of the objects that you used in the previous experiment, provide aquaria, terraria, mice or gerbils (preferably breeding ones), insects, flowering and non-flowering plants, plants with roots showing, seeds, rocks, fossils, bones, and/or a playing tape recorder. To illustrate "growth" include one plant variety in several stages of development. One-third of the stations should be plants, one-third should be animals, and one-third should be non-living items. Stations should be set up throughout the classroom and a procedure should be established by which each student has ample time to record the observations at each station. You may want to duplicate additional copies of the student sheet if you wish to include a large variety of living and non-living things.



INVESTIGATION # 1: ORGANISM

Name____________
Section____Date____

THE IDEA

Table 1-3

Key Characteristics of Living Things	Evidence Observed

1. List three important differences between the non-living object shown and a living thing.

   Non-living things cannot eat, move by themselves, breathe, reproduce.

2. How can you distinguish one living thing from another?

   Each type of living thing has its own characteristics.

3. What idea do the data allow you to state?

   AN ORGANISM HAS CERTAIN CHARACTERISTICS THAT DISTINGUISH IT FROM NON-LIVING THINGS.

Before the class discussion, prepare a class data chart similar to Table 1-3 and display the chart on the chalkboard or on an overhead projector. Pass out the student sheet labeled "The Idea." To begin the discussion ask the students to share their observations of the living and non-living items. As the students provide the observable characteristics of living things, add each of them to Table 1-3. Emphasize those characteristics that were actually observed by the students. The idea of synthesis and regulation may be suggested by the students, but those discussions should be saved for the Life Processes portion of this course. Ask the students how they know that each is a characteristic only of living things. Continue the discussion using the questions on The Idea sheet.

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INVESTIGATION # 1: ORGANISM

Name_______________
Section_____Date_____

EXPANSION OF THE IDEA

Cold water

1. Set up a container of aquarium water as directed by your teacher. Record the initial temperature of the water: _________° C.

2. Place a goldfish into container. Allow 2-3 minutes for the fish to calm down.

3. Count the number of times the mouth of the fish opens for one minute. Wait one minute, then count the number of mouth openings occurring in the next minute. Record these data on Table 1-4.

Table 1-4

	Number of Mouth Openings in Aquarium Water at:		
	Initial Temperature	Cold Temperature	Changes in Number of Mouth Openings
Minute One			
Minute Two			
Average			

4. Set the container with fish in an ice bath until the temperature of the aquarium water is 5° C lower than the initial temperature. Count the mouth openings for one minute. Wait one minute, then count the number of mouth openings in the next minute. Record these data on Table 1-4.

5. What effects did the change in the temperature have on the behavior of the fish?

   The fish may swim faster at first, then slower than normal; the number of mouth openings increase.

6. What effect did the change in temperature have on the number of mouth openings per minute of the fish?

   The number of mouth openings decreased when the temperature was colder.

7. What might happen to the fish if the temperature change went beyond a certain limit?

   The fish might die.

The students should fill a container half full of aquarium water. The container may be a jar, beaker or small clear plastic box. Record the initial temperature.

Using a fish net, collect a goldfish and place in the aquarium water. Remind students to treat the fish alike except for the temperature.

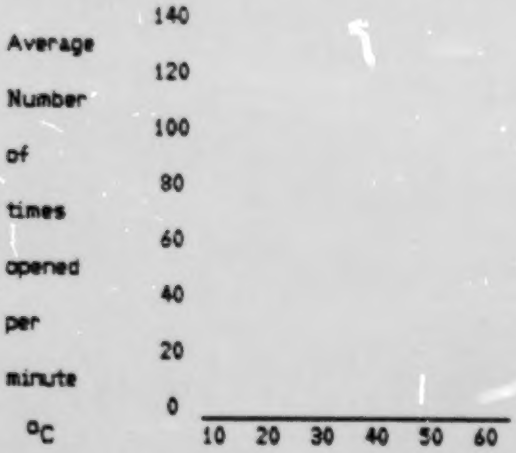
Students may count mouth openings for 10 seconds then multiply by six to get the number of openings per minute. Repeat the procedure for a second count. You may wish to calculate the average per minute.

Prepare an ice bath using a container of ice large enough for the aquarium water container to set down in the ice. One ice bath per group is suggested.

Some fish become quite active when transferred from an aquarium alone, and/or experience changes in temperature. Warn students to be aware of extreme changes in fish behavior and to allow the fish to "calm down" before counting begins. You may have some groups count the mouth openings of the fish in higher temperatures by preparing a hot water bath. (NOTE: Small gold fish cannot survive temperature above 35° C.)

Before class discussion, prepare a class data chart and display it on the chalkboard or on an acetate sheet for the overhead projector. Have each group post their data before beginning the class discussion.

Using class data, you may wish to have the students plot a graph of the average number of times the mouth (gill covers) opened per minute at each temperature.



Have the students graph their own data, then the data of the other groups. In the discussion have the students look for trends and any differences.

During the class discussion ask the following:

Explain why or why not the fish would be able to "keep healthy" if the aquarium was kept above 35° C or below 10° C? (The extreme temperatures exceed the living tolerance of the fish.)

Discuss the goldfish tolerance ranges:

The maximum temperature of 35° C is called an UPPER LIMIT for this environmental variable.

The minimum temperature of 10° C is called the LOWER LIMIT for this environmental variable.

The range between the upper and lower limits is said to be the limits of tolerance (or just "TOLERANCE").

Define the term variable for the student, using temperature as an example.

What other environmental variables (besides temperature) changed during this experiment? (None were changes; some students may notice fish size as variable.)

What environmental variables remained unchanged during the experiment? (Light, amount of water, the fish, or the container.)

What would happen if the temperature and the type of water of the fish were changed during the same experiment? (The results would not be clear. You would not know if it was the type of water or the temperature of the water that produced the results.)

Why do you think you did more than one test on the fish then took an average? (More tests provide more data from which to draw a conclusion.) A poorly done experiment or a sick or stressed fish could be compared to other normal tests.

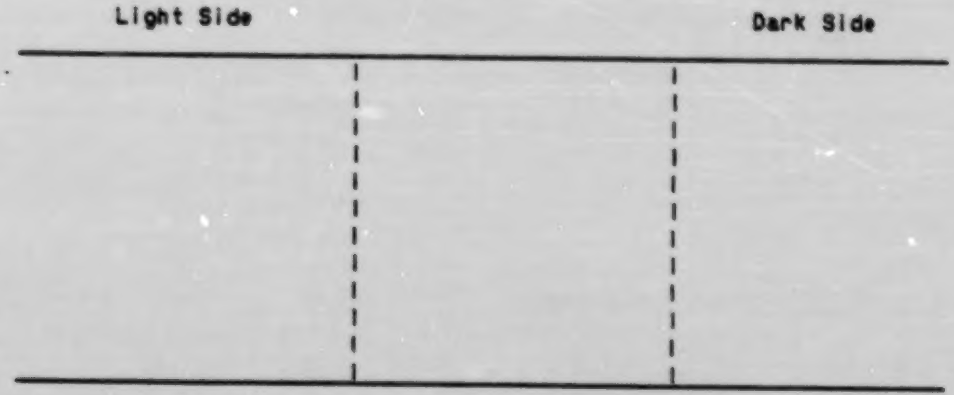
Optional: Worm Tracks

Purchase earthworms from a bait shop or have students collect them. Direct the students in the following manner:

Prepare a dissecting tray or cardboard box so that about a third of the tray is covered by a translucent or transparent material, such as acetate or plastic wrap. Over the opposite end place an opaque material such as cardboard or construction paper. Leave the middle one-third open. A moist paper towel should be placed across the bottom of the tray so that the worm will not dry out.

Gently place a worm in the center section of the tray. As the worm moves, trace its path on The Racing Chart. Continue tracing until the worm stops moving.

Racing Chart



Repeat the procedure with several worms, using different colored lines to show the path of each worm. Discuss the variables of the experiment and the effect of light on the earthworm.

INVESTIGATION #1: ORGANISM

Name____________________
Section_____Date______

EXPANSION OF THE IDEA

Reading Questions: Supplying the Needs

1. What needs of an animal are supplied by vegetation?

   Food, cover, and sometimes water.

2. What changes occur when a dam is built?

   Some areas behind the dam become flooded and other areas may dry up making water a limiting factor. A few students may bring in the idea that the reservoir behind a dam has a fluctuating water level. This makes it difficult for any organisms (plant or animal) to become permanently established in this area.

3. Describe the habitat in which a bird with the following foot adaptations might live. Be sure to include all factors of the habitat in your description.

   The first illustration describes aquatic habitat--including type of food and cover available.

   The second illustration describes forest habitat--food and cover different from the first illustration.

4. Select one of the ways in which man changes wildlife habitat____.

   Housing developments, industrial areas, transportation systems, and pollutants will dramatically reduce the habitat needs of many organisms.

   In what ways might this kind of change affect a cottontail rabbit?

   Answers will vary. For example, if fields or forests are cleared and burned to provide an area for a new housing development the cottontail rabbit will be deprived of food and cover and possibly water.

TEACHER'S GUIDE

INVESTIGATION #2: CLASSIFICATION

EXPLORATION

Observing Insects

CONCEPTUAL INVENTION (THE IDEA)

Observable characteristics of organisms allow them to be classified.

EXPANSION OF THE IDEA

Classification of Organisms

Reading: Classifying Organisms

Optional: Sorting Things Out

INVESTIGATION #2: CLASSIFICATION

INTRODUCTION

The concept of this investigation is: Observable characteristics of organisms allow them to be classified.

The Exploration Phase allows the students to observe and group organisms according to similarities and differences. The students develop their own simple classification key by collecting, sacrificing, and pinning insects. Collection of the insects is done on a field trip or as homework. This activity will lead the students to invent the concept.

During the Expansion Phase, the students will experience the use of classification keys. Students should be provided with keys appropriate for your area. Keys for your specific region may be obtained from such institutions as state universities, forestry services and wildlife departments. The reading applies the classification scheme to a larger group of organisms and informs the student of the Linnaean Taxonomic system. The teacher may choose to add another experiment in which the students classify organisms from different kingdoms or phyla. The three kingdom approach is suggested for use with the concrete operational student. Other modern taxonomical schemes may be mentioned.

The concept is expanded to include the following related content: scientists use classification keys to identify living organisms; organisms with the same characteristics belong to a single species; scientists use a universal system of naming organisms; many scientists divide living organisms into three kingdoms (plant, animal, protista); as the groups become smaller, the organisms within these groups become more closely related; and, classification systems are man-made systems and are subject to change as more information becomes available. The equipment you will need for this investigation follows.

EXPLORATION

Observing Insects

insect pins
collecting jar
dissecting tray or cardboard box
kill jar*
collecting nets
bug box
hand lens
dissecting scope

*Kill Jar: Small jar and lid; plaster of Paris; ethyl acetate, and blotter paper (filter paper, paper towel).

Add about three-fourths inch of plaster to each jar and allow to dry. Pour ethyl acetate onto the plaster. The plaster will absorb the ethyl acetate. You will need to recharge the kill jar occasionally. Cover the plaster with a piece of filter or blotter paper. This will absorb moisture from the insects. The lids should fit tightly.

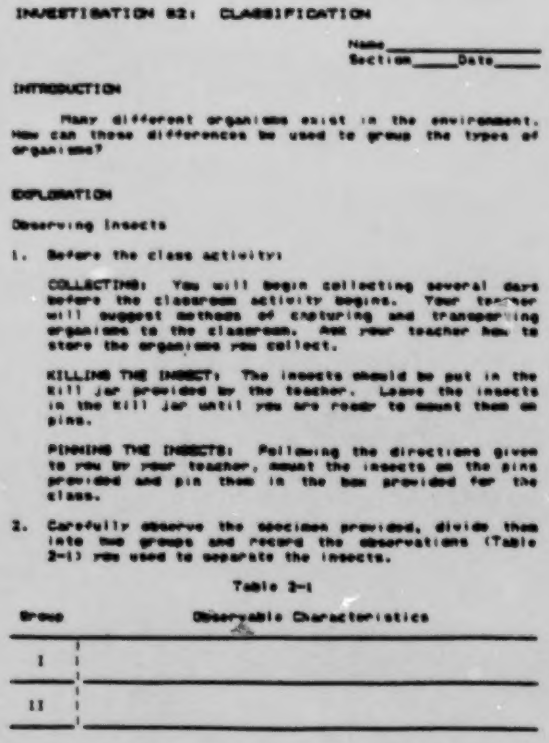
EXPANSION OF THE IDEA

Classification of Organisms

Obtain classification keys suitable for your region and organisms to be identified.

Optional: Sorting Things Out

Obtain representative organisms of the kingdoms or phyla to be classified.



INVESTIGATION #2: CLASSIFICATION

Name________________
Section_____Date_____

INTRODUCTION

Many different organisms exist in the environment. How can these differences be used to group the types of organisms?

EXPLORATION

Observing Insects

1. Before the class activity:

COLLECTING: You will begin collecting several days before the classroom activity begins. Your teacher will suggest methods of capturing and transporting organisms to the classroom. Ask your teacher how to store the organisms you collect.

KILLING THE INSECT: The insects should be put in the kill jar provided by the teacher. Leave the insects in the kill jar until you are ready to mount them on pins.

PINNING THE INSECTS: Following the directions given to you by your teacher, mount the insects on the pins provided and pin them in the box provided for the class.

2. Carefully observe the specimen provided, divide them into two groups and record the observations (Table 2-1) you used to separate the insects.

Table 2-1

Group	Observable Characteristics
I	
II	

Several days before beginning the classroom activity, have the students start to collect the organisms. Each group should collect ten organisms. Use class time or assign collecting as homework. All specimens collected at home should be turned in before school starts each day. Warn the students that some organisms bite or sting! If the students are looking under rocks and boards, for example, they should beware of such organisms as spiders, snakes and scorpions. At night, shine a light on a white surface, such as a sheet, to attract insects for collection.

Provide a common storage area for all insects collected by your classes. This will enable you to choose the insects for each group, thus insuring that all will have a variety of insects to classify. NOTE: If you wish to store insects for use during the following year, be sure to use paradichlorobenzene (mothballs).

3. Observe the characteristics of the insects within each group. Divide Groups I and II into two subgroups each. Record your observations in Table 2-2.

Table 2-2

	Subgroup	Observations
Group I	IA	
	IB	
Group II	IIA	
	IIB	

Discuss the characteristics of insects with your class. Collection of all kinds of 'bugs' or 'animals without backbones' will work. Very specific instructions and demonstrations of sacrificing and pinning the insects are needed. Insure that each set of specimens consists of several Classes or Orders. You may need to combine the student collections. Provide several sets of insects with a variety of observable characteristics that are readily divided into groups by the students. Example: Choose eight to ten insects (winged - wings covered) for each group to observe.

You will need enough sets of insects to allow all the groups in your largest class to have one set each (Example: groups of four with twenty-eight students--seven sets of insects). The insects may be pinned on dissecting trays, double thick cardboard, in cigar boxes, or on styrofoam.

Have each group take one set of insects to their table. Working in groups, the students should first divide the insects into two groups and record the characteristics used to separate them. As the students work, encourage them to use their observational skills from Investigation One.

INVESTIGATION #2: CLASSIFICATION

Name________________
Section_____Date_____

THE IDEA

1. What characteristics did you observe that were common to all insects?

   Six jointed legs; hard outer shell; three body parts; antennae; eyes; possibly wings

2. What characteristics did you observe that were different among the insects?

   Wings—number or type of wings; color, size

3. How did you use these similarities and differences to group the insects?

   Answers will vary. For example, the presence of wings might have been used to divide the insects into two groups.

4. What idea do the data allow you to state?

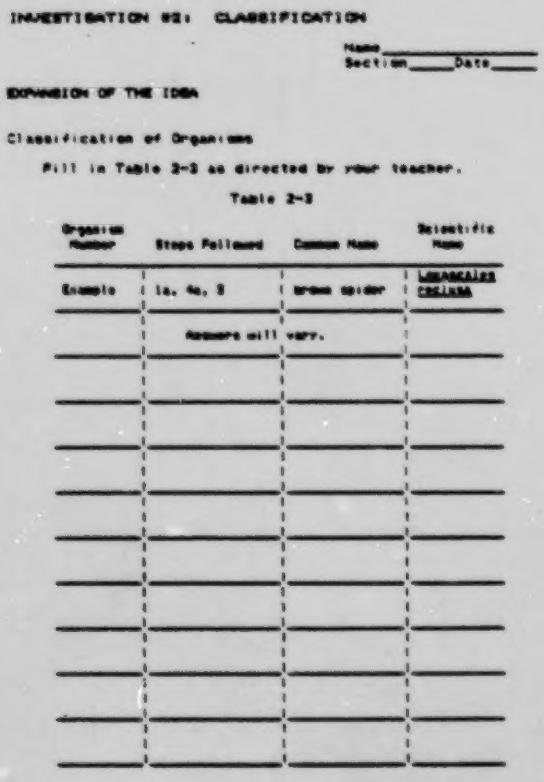
   OBSERVABLE CHARACTERISTICS OF ORGANISMS ALLOW THEM TO BE CLASSIFIED.

Pass out The Idea sheet to the students. Allow them time to answer the questions before beginning the discussion. Go over The Idea questions. Tell them that grouping of organisms using similarities and difference in characteristics is called classification. Choose one organism and ask several students to give it a name. Record these names. Ask the students what problems are caused when different names are used for a single organism. This should illustrate the need for a universal system of naming organisms. You may want to discuss this briefly.

Tell students to look at one of their groups. Ask them why all of these go in that group (because they are similar). Ask them why they didn't include other organisms in that group (because they are different). Have the students look at all the groups and subgroups.

Ask: what is happening to the numbers in each group? (getting smaller); what is happening to the characteristics of the groups as they get smaller? (they more closely resemble one another); and, what could be said about organisms that closely resemble one another? (related). Caution: Do not expect the concrete students to go beyond observable characteristics.

If none of the groups consist of only one insect, you may want to have the class continue dividing a group until you have isolated one insect. When a single organism has been isolated, ask: what do we call a group of organisms with the same characteristics? (species)



INVESTIGATION #2: CLASSIFICATION

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Classification of Organisms

Fill in Table 2-3 as directed by your teacher.

Table 2-3

Organism Number	Steps Followed	Common Name	Scientific Name
Example	1a, 4a, 3	brown spider	Loxosceles reclusa
	Answers will vary.		

The activity will enable the students to become familiar with a segment of the organism they will be observing during the year. Suggested organisms to identify are trees, insects, flowers, grasses, "weeds".

Simplified keys should be used if at all possible. Use keys that work accurately for the locality where you will be performing most of your studies. For instance, if your classes will be working in a wooded area, give them experience using a tree key; if in a grassland, use a simple key to the grasses. Insects are a good animal to learn how to identify since they are found in most habitats. Concrete students have difficulty using complicated classification keys.

The teacher may wish to use a computer program on classification. For example, "The Animal Game" for the Apple II computer might work well to complete this investigation.

There are several texts and articles that include paper and pencil classification ideas. For example, Butzow, John W. and Philip N. Kane "Can Fish Catch On in Your Class?" The Science Teacher, September, 1983.

Optional: Sorting Things Out. For those students or classes that need more time to accommodate the concept or for those showing great interest, you may wish to add additional opportunities for classifying. Provide Organisms representative of the Plant, Animal, and Protist Kingdoms. It is suggested that you provide twenty to twenty-five organisms for observation. Have the students move from station to station at specific times. This will insure that each organism is observed. Have the students group the organisms as they did the insects, using observable characteristics. This activity may lead to a discussion of Linnaeus' taxonomic system.

Table 2-4

Organism	Kingdom	Phylum	Class
1. King Crab	Animalia	Arthropoda	Crustacea
2. Minnow	•	Chordata	Pisces
3. Horny toad	•	•	Reptilia
4. Tick	•	Arthropoda	Arachnida
5. Opossum	•	Chordata	Mammalia
6. Monarch butterfly	•	Arthropoda	Insecta
7. Golden eagle	•	Chordata	Aves
8. Daphnia	•	Arthropoda	Crustacea
9. Black rat snake	•	Chordata	Reptilia
10. Homo sapiens	•	•	Mammalia

11. What are the main differences between the plant and animal kingdoms?

    Plants cannot move on their own, most animals can.

12. List three observable characteristics of mammals that distinquish them from all other animals.

    The females have mammary glands to supply their young with milk; mammals have hair on their bodies; the females give birth to living young.

TEACHER'S GUIDE

INVESTIGATION #3: POPULATIONS

EXPLORATION

Organisms at a Study Site

CONCEPTUAL INVENTION (THE IDEA)

A population is a group of organisms of the same species affected by environmental variables in the habitat.

EXPANSION OF THE IDEA

Habitat Limits

Increasing Numbers

Reading: Limiting Factors Controlling Animal Populations

INVESTGATION #3: POPULATIONS

INTRODUCTION

The concept of this investigation is: A population is a group of organisms of the same species affected by environmental variables in the habitat. If the students need help in estimating population size, you may wish to include the optional activity to train the students in obtaining a representative sample.

During the Exploration phase, the students will estimate the size of two natural populations from different areas. A comparison of the population size will be used to determine some of the factors which limit populations. This activity will allow the student to invent the concept.

During the Expansion phase, a population game will expand the concept to include carrying capacity. Examination of fruits will apply the concept to the idea of biotic potential. The reading applies the concept to animal and human populations. Discussion of limiting factors should be restricted to those that are observable. The more complex interactions should be avoided until Ecosystems.

The concept is expanded to include the following content: a population is affected by the carrying capacity of its habitat; the kinds of populations in a habitat are influenced by various limiting factors; organisms have different biotic potentials; and, the carrying capacity of a habitat may vary. The equipment you will need for this investigation follows.

EXPLORATION

Organisms at a Study Site

cardboard (20 cm x 20 cm)
string
Optional: thermometers, light meters
nails
meter stick

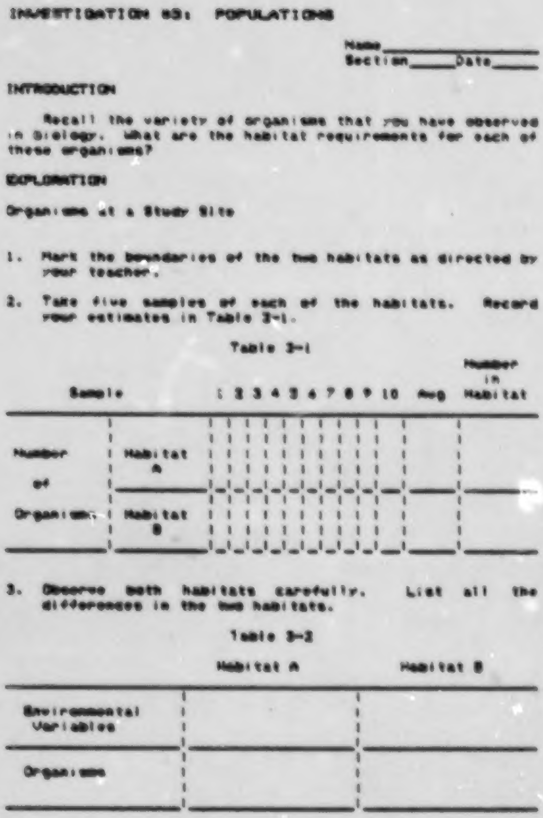
EXPANSION OF THE IDEA

Habitat Limits

beans or colored
popcorn (about 350)
stakes for boundary markers
timer
sandwich bags (75)

Increasing Numbers

fruits (bean pods, tomatoes,
apples, or oranges), fruit flies
or *Tribolium* beetles



INVESTIGATION #3: POPULATIONS

Name________________
Section_____Date_____

INTRODUCTION

Recall the variety of organisms that you have observed in biology. What are the habitat requirements for each of these organisms?

EXPLORATION

Organisms at a Study Site

1. Mark the boundaries of the two habitats as directed by your teacher.
2. Take five samples of each of the habitats. Record your estimates in Table 3-1.

Table 3-1

Sample		1	2	3	4	5	6	7	8	9	10	Avg	Number in Habitat
Number of Organisms	Habitat A												
	Habitat B												

3. Observe both habitats carefully. List all the differences in the two habitats.

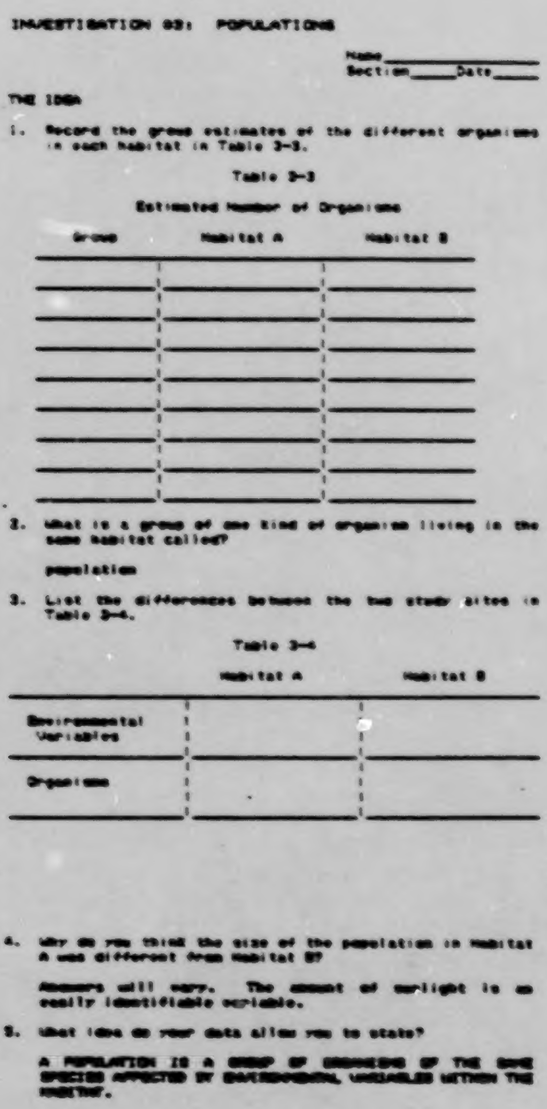
Table 3-2

	Habitat A	Habitat B
Environmental Variables		
Organisms		

For the students who have difficulty in establishing sampling techniques, you may wish to train them in a particular method. Ten samples, if taken randomly, will provide ten-percent coverage of the quadrant. Many ecologists feel this amount is necessary for accurate sampling. Select habitats on or near the school grounds where different kinds of plants and animals live. These may be areas adjacent to your school, a natural area within a short walking distance, or a field trip to an area that has a variety of habitats, such as a woodland, field, pond, lake or river. On the field trip, provide a map of the study area showing the specific areas for study or walk them through the area when you arrive. The areas chosen should have a recognizable difference of population size and the factor affecting the population. (Example: Bermuda grass - full sun vs. shade.) Mark the study areas clearly.

Before class, choose a population and determine its population size for two given areas. This should be a natural population, such as Bermuda grass, clover, or dandelions. Provide the students with specimens or detailed descriptions of the organism to be counted.

To complete Table 3-1, have the students count the number of the assigned organisms in the habitats. After the students have taken samples, average the counts, and then multiply the average by the number of times the sample size fits into the habitat. As the students work, observe the sampling techniques and provide help when needed. To complete Table 3-2, have the students recall the environmental variables discussed in Investigation One. The 'organism' portion of the table should include plants and animals.



INVESTIGATION 03: POPULATIONS

Name________________
Section_____Date_____

THE IDEA

1. Record the group estimates of the different organisms in each habitat in Table 3-3.

Table 3-3

Estimated Number of Organisms

Group	Habitat A	Habitat B

2. What is a group of one kind of organism living in the same habitat called?

population

3. List the differences between the two study sites in Table 3-4.

Table 3-4

	Habitat A	Habitat B
Environmental Variables		
Organisms		

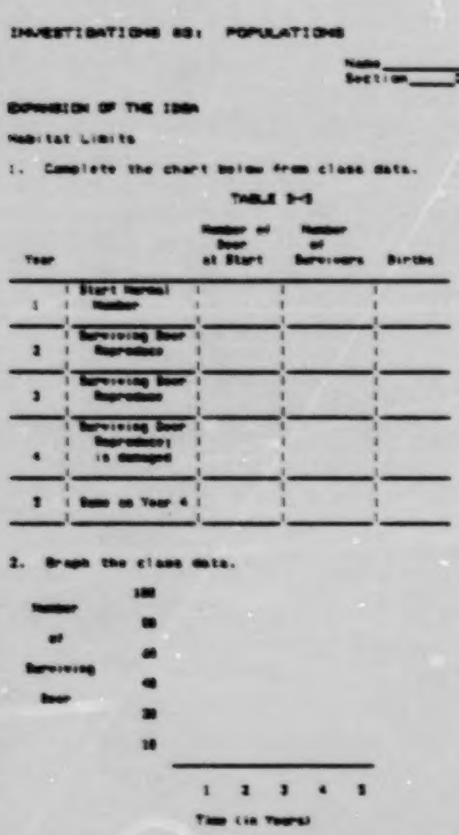
4. Why do you think the size of the population in Habitat A was different from Habitat B?

Answers will vary. The amount of sunlight is an easily identifiable variable.

5. What idea do your data allow you to state?

A POPULATION IS A GROUP OF ORGANISMS OF THE SAME SPECIES AFFECTED BY ENVIRONMENTAL VARIABLES WITHIN THE HABITAT.

Pass out The Idea sheet and display Table 3-3 and Table 3-4. Ask each group to share the estimated size of the population. Record these figures on the chalkboard. As the students share their data from Table 3-4, record these on the class chart. Discuss the questions on The Idea sheet. Ask the students to choose the environmental variable that differs the greatest from Habitat A to Habitat B. Restrict the discussion to a one-to-one or linear relationship, e.g., because there is more light in one habitat, the bermuda grass grows better.



INVESTIGATIONS #3: POPULATIONS

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Habitat Limits

1. Complete the chart below from class data.

TABLE 3-5

Year		Number of Deer at Start	Number of Survivors	Births
1	Start Normal Number			
2	Surviving Deer Reproduce			
3	Surviving Deer Reproduce			
4	Surviving Deer Reproduce; is damaged			
5	Same as Year 4			

2. Graph the class data.

This activity consists of five one-minute "years." The students will collect food for survival of a deer population.

Before class, clearly mark the habitat. A circle ten meters in diameter is a manageable area. Before the game starts, scatter the deer food (ten popcorn kernels or beans per student) in the habitat.

Prepare a large data sheet of Table 3-5. Assign one student as timer. NOTE: Before the fifth year, you could add two additional home ranges. If you decide to do this, mark two areas near the "home range." Add five beans per student to these areas. These areas will allow the "deer" to disperse or migrate after the home range carrying capacity is reduced. If you decide not to do this, include dispersal and migration in the discussion.

Tell the students that they are going to play a population game to obtain data quickly rather than over a long period of time. Explain to the students that in the game they will each have a plastic bag. Each bag represents a deer. Ask students what all the students with the bags would represent (a population). Tell students that the beans in the circle represent the plants that the deer need as their food supply. They are to collect food for the animals in the herd for a period of five "years."

For a deer to survive a one-minute "year," it must have collected at least five beans. Students may collect more than five food beans per deer, but not more than ten. Sharing or pooling of beans of different players is not permitted in this game. Use the whistle to begin and end each round. Students who are eliminated early may be assigned to record or count data.

At the end of each round, collect the deer bags that have not survived that round. At the beginning of each round, hand out an additional bag for each deer that survived to represent reproduction.

Return to the classroom and have students graph the class data. Allow the students time to transfer data from the class chart to their own sheets. You may need to review the game to help the students organize their thoughts. Direct the students to prepare line graphs of their data (time in years on the x-axis and number of deer on the y-axis). Assist students in preparing graphs. Connect the points consecutively in black. The number of individuals that an area can support within its available resources is called its carrying capacity. Exact instructions for the game follow.

GAMES INSTRUCTIONS

ROUND ONE--Year 1: Give each student one bag to represent one deer; allow them to collect the food beans for one minute; prolong or shorten the year as necessary, but keep it the same throughout; at the end of the allotted time, record how many deer survived; record the data and collect the "deer" that did not survive.

ROUND TWO--Year 2: Ask students how populations grow (reproduction), explain that they will simulate reproduction and add one deer for every deer that survived the first year; hand out additional bags, all of the participants should now be collection food for two deer; redistribute the food beans in the habitat; point out the number of deer entering Year 2 and begin; at the end of the round, record the number of deer surviving on the data board, as data is collected it may be helpful to have students raise fingers as to how many deer survive in each subsequent round of the game, collect the casualties; and, ask the students if three horses can live on two acres of land or ask them if the town's population could exist solely on the city land without ever leaving the area, lead them to the invention of the term carrying capacity as the greatest number of animals of one kind that can survive in a certain area, ask them to estimate the carrying capacity for this habitat, how did they come to this estimate?

ROUND THREE--Year 3: Surviving deer will again reproduce, so each surviving deer should be given an additional bag, some students now may be collecting food for as many as four deer; redistribute food beans in the habitat; ask students for their predictions and record these on the data board; and, play Round Three exactly as Round Two was played and record results on the board.

ROUND FOUR--Year 4: Distribute one more bag for every deer that survived; tell students that due to the large number of deer feeding on the home range last year, the plants that deer ate have been damaged and food production has been lowered; remove one quarter of the food supply and redistribute the remainder in the habitat; ask students to note the number of deer entering the round, what we have changed (we have increased the population and decreased the food supply), and how many deer will survive now; play the round and record the results.

ROUND FIVE--Year 5: Collect bags of those deer that did not survive; pass out bags to survivors; redistribute the reduced food supply; play the round and record results. If you chose to add the additional habitats include the following: ask the group how a population could survive if the habitat did not produce enough food to feed the population of deer (they would look for a new food supply); introduce the term "dispersal" or "migration"; in Round Five, after all the available food in this round is eaten, they may disperse and look for new areas; redistribute one more bag for each surviving deer; redistribute the reduced number of beans (the same number used in Round Four); play the round and call the group together, ask how dispersal affected survival; and, ask if all animals can migrate to different areas, what would happen to those animals not able to migrate when their habitat's carrying capacity is reduced?

3. What do we call the number of individuals an area can support?

carrying capacity

4. What is the limiting factor for the deer's habitat?

food

5. List other factors that may affect the carrying capacity of a habitat.

water, light, temperature, shelter, space

6. If a person regularly, and for a long time, provided a lot of corn for a population of deer in a small area, what would happen to the carrying capacity of that area for deer? What would be the effect on the deer if the person moved away?

The carrying capacity would increase with the presence of additional food, but would decrease drastically when the additional food source was removed. That is, the population of the deer might have increased and these additional deer could not be fed by the original carrying capacity.

INVESTIGATION #3: POPULATIONS

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Increasing Numbers

1. Estimate the number of offspring produced by one parent. Record this number on Table 3-6.

Table 3-6

Parent	Offspring

2. Calculate the following information: Number of possible offspring if all the young of the parent survive________. Amount of space required for all of the offspring________________.

3. Complete the chart below.

Table 3-7

Organism	Number of Young Produced During Life Span	Possible Number of Young Produced by Offspring
Corn	6,000	36,000,000
Dog	20	400
Man	4	16

4. The number of offspring a parent can produce is called biotic potential.

5. List your evidence that shows what would happen if all organisms reached their full biotic potential.

Some fruits have many seeds. If seed grew, all of the space would be taken.

6. Give two reasons why organisms do not attain full biotic potential.

Eaten by animals; may not fall on a suitable growing medium; environmental variables not within the tolerance range.

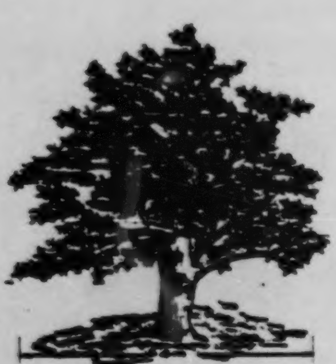
Fruits or vegetables which have easily observable seeds are recommended for this activity: bean or pea pods, okra, apples, corn, pumpkins, or tomatoes. You could ask the students to bring various fruits or your local grocery produce manager may have damaged merchandise to donate. Discuss with the class the definition of a fruit. It is not necessary that all groups have the same fruit. You can assign groups certain plants according to their math skills.

The yield and amount of space required for each plant can be found on seed packets, seed catalogs, or you can discuss the needed information with each group.

Observe each group as they calculate the answers. The numbers used in the chart should be presented as "possibilities," not actual values. You may want to discuss this.

The teacher may need to give an example as to how students can calculate the space required by a plant. For example, the width of the tree shown is four meters.

If you have students with good math skills, you may wish them to use $A_0 = \pi r^2$.



INVESTIGATION #3: POPULATIONS

Name__________________
Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: Limiting Factors Controlling Animal Populations

1. What are the major limiting factors controlling animal populations in the following regions of the U. S.? Provide one example for each region.

Table 3-8

Region	Limiting Factor(s)	Example
a. north	cold, dry, decreased coverage and food supply	limits chigger population
b. south	warm and moist prolonged heat	pheasant population
c. east	parasites (brainworm)	elk population
d. west	variable; loss of cover, dry	lack of water limits many populations

2. What limiting factors do man's activities impose on all animal populations?

habitat destruction; hunting; poaching

3. Choose a natural population in your state. Give one example of how a limiting factor has restricted the size of this population.

Answers will vary. For example, a hard winter may kill many populations.

4. Defend or refute the following statement: hunting is bad for a deer population.

Refute: **Controlled hunting will lower the population size so it stays within the carrying capacity.**

Defend: **Uncontrolled hunting can eliminate a population.**

TEACHERS'S GUIDE

INVESTIGATION #4: PRODUCERS

EXPLORATION

Light and Dark

Variegated Leaves

CONCEPTUAL INVENTION (THE IDEA)

Green plants use light to make their own food and are known as producers.

EXPANSION OF THE IDEA

Starchy Foods

Reading: Death of a Producer

Optional: Carbon Dioxide and the Green Plant

INVESTIGATION #4: PRODUCERS

INTRODUCTION

The concept of this investigation is: Green plants use light to make their own food and are known as producers. Through investigations, the student will determine that starch production occurs in the green pigmented area of a leaf that is kept in the light. Controlled experiments are used to develop the concept.

During this investigation, photosynthesis is treated as a process requiring specific conditions for the production of food (starch). (An understanding of the light and dark phased reactions of photosynthesis requires formal thought and cannot be understood by the concrete operational tenth grade student). The presence of starch in foods is tested. Also, the concept will be expanded by a reading. Audiovisual aids may be added: The Nova production "The Green Machine" has been used successfully. This film includes many plant phenomena not mentioned in this learning cycle, but may provide several topics for discussion.

The concept is expanded to include the following related content: light and chlorophyll are necessary for starch production; producers store food as starch; and, photosynthesis is the process by which green plants make their own food. The equipment you will use for this investigation follows.

EXPLORATION

Light and Dark

Swedish ivy or geranium plants
young bean plants
500 ml. beakers
250 ml. beakers
ethyl alcohol (if not available, use methyl alcohol)
Lugol's iodine (potassium iodide)
petri dishes or microscope slides
hot plate
forceps
colored pencils (optional)
gooseneck lamps or intense light source
safety goggles

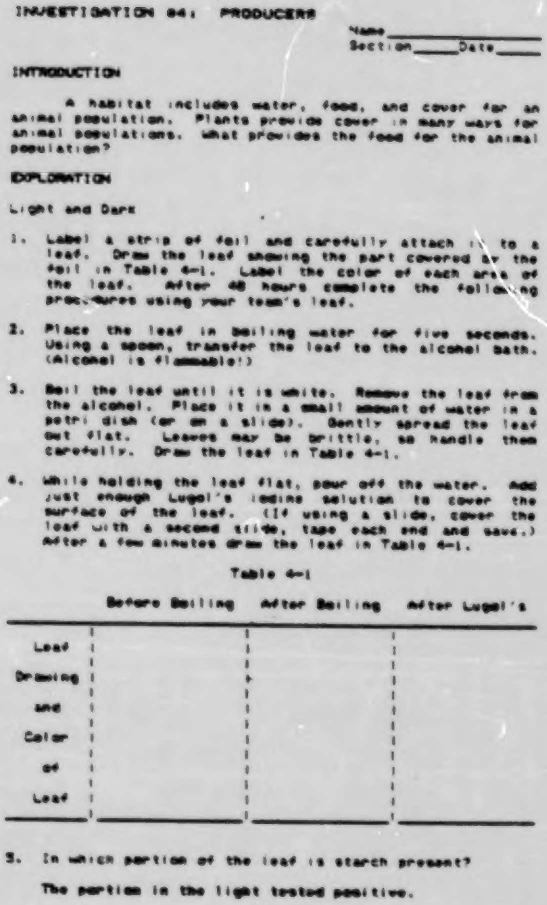
Variegated Leaves

Coleus or swedish ivy with green and white leaves
(same materials as for Light and Dark)

EXPANSION OF THE IDEA

Starchy Foods

spot plate
food samples: ice cream; onion; rock; potato; potato chips; seeds; corn; bacon; tuna fish; chicken; beef; egg white (raw); and, a seed part (cotyledon) of a bean plant
Lugol's Iodine solution: dissolve Iodine, 50.0 g.; potassium iodide, 100.0 g.; and, distilled water, to make 1000 ml.



INVESTIGATION #4: PRODUCERS

Name________________
Section_____Date_____

INTRODUCTION

A habitat includes water, food, and cover for an animal population. Plants provide cover in many ways for animal populations. What provides the food for the animal population?

EXPLORATION

Light and Dark

1. Label a strip of foil and carefully attach it to a leaf. Draw the leaf showing the part covered by the foil in Table 4-1. Label the color of each area of the leaf. After 48 hours complete the following procedures using your team's leaf.
2. Place the leaf in boiling water for five seconds. Using a spoon, transfer the leaf to the alcohol bath. (Alcohol is flammable!)
3. Boil the leaf until it is white. Remove the leaf from the alcohol. Place it in a small amount of water in a petri dish (or on a slide). Gently spread the leaf out flat. Leaves may be brittle, so handle them carefully. Draw the leaf in Table 4-1.
4. While holding the leaf flat, pour off the water. Add just enough Lugol's iodine solution to cover the surface of the leaf. (If using a slide, cover the leaf with a second slide, tape each end and save.) After a few minutes draw the leaf in Table 4-1.

Table 4-1

	Before Boiling	After Boiling	After Lugol's
Leaf Drawing and Color of Leaf			

5. In which portion of the leaf is starch present?

The portion in the light tested positive.

Using healthy plants, direct the students to mark their group identification symbol on a strip of foil or construction paper. The students may attach the foil with tape or a paperclip. Leaves may be chosen at random, but, the younger leaves provide the best results. Place the plants so that each receives an adequate amount of light.

Two (or more) days later, have the students test their leaf according to the procedures outlined. You may wish to set up only two or three alcohol baths or one for each group of students. Hot plates should be used in place of Bunsen burners to reduce the fire hazard. The room should be kept well ventilated, and students should wear goggles while the alcohol is being boiled.

Add a small amount of water to the petri dish (or on the slide) to aid in spreading the leaf out flat. Use colored pencils for the drawings or have the students state the colors present.

NOTE: To prepare leaves so that they can be preserved and stored for use later, use the procedure that follows: cut a leaf lengthwise into two equal halves; perform the starch test as directed on the student sheet using the slide instead of a petri dish; cover the leaf on the slide with a second slide and tape the ends of the two slides together. By using this method, the leaf slides can be saved indefinitely.

INVESTIGATION #4: PRODUCERS

Name________________
Section____Date_____

EXPLORATION

Variegated Leaves

1. Remove one variegated leaf from the plant. Draw the leaf on Table 4-2 and label the color of each area of the leaf. Complete the following procedures using the leaf you removed.
2. Place the leaf in boiling water for five seconds. Using a spoon, transfer the leaf to the alcohol bath. (Alcohol is flammable!)
3. Boil the leaf until it is white. Remove the leaf from the alcohol. Place it in a small amount of water in a petri dish (or on a slide). Gently spread the leaf out flat. Leaves may be brittle, so handle them carefully. Draw the leaf in Table 4-2.
4. While holding the leaf flat, pour off the water. Add just enough Lugol's iodine solution to cover the surface of the leaf (if using a slide, cover the leaf with a second slide, tape each end and save). After a few minutes draw the leaf in Table 4-2.

Table 4-2

	Before Boiling	After Boiling	After Lugol's
Leaf Drawing and Color of Leaf			

5. In which portion of the leaf is starch present?

The green portion has starch.

Green and white Coleus or Swedish ivy work well, but green and purple Coleus or other variegated plants may be used.

The teacher may wish to have the students predict the presence or absence of starch in variegated leaves.

Instruct students to perform the same type of Lugol's Iodine test as used in "Light and Dark". (These same procedures are outlined on their lab sheets for this part.) Remind students of the safety precautions.

INVESTIGATION #4: PRODUCERS

Name________________
Section____Date_____

THE IDEA

1. Summarize the class data on Table 4-3.

Table 4-3

Plants Placed in the Light:

	Group	Covered Area	Uncovered Area	Green Area	Non-Green Area
Starch was Present in the leaf (Check, if yes)	1		x	x	
	2		x	x	
	3		x	x	
	4		x	x	
	5		x	x	
	6		x	x	
	7		x	x	

2. What substance is produced by plants in the light?

starch

3. What color (or pigment) must be present for starch to be made?

green (or chlorophyll)

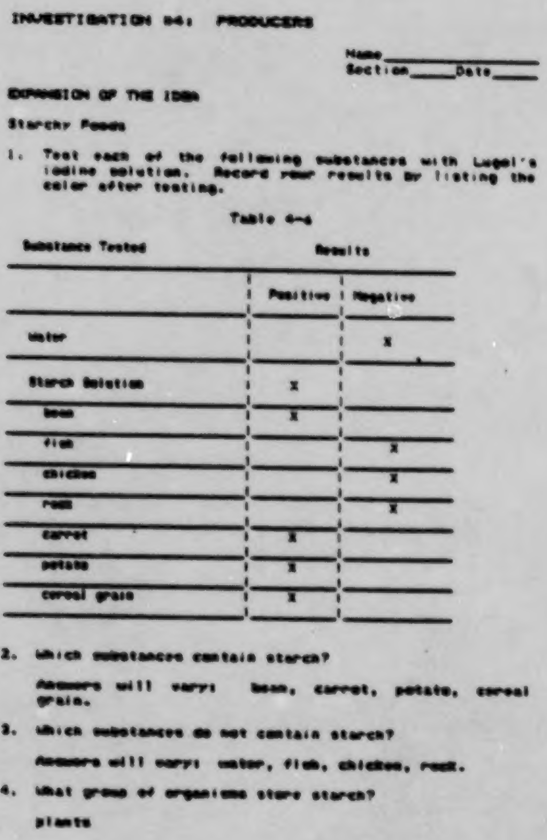
4. List the things that are needed by plants to produce starch.

light and chlorophyll (carbon dioxide will be added later)

5. What idea do the data allow you to state about green plants?

GREEN PLANTS USE LIGHT TO MAKE THEIR OWN FOOD AND ARE KNOWN AS PRODUCERS.

Hand out The Idea sheet and place a blank copy of it on the overhead. Begin the class discussion by recording each group's data on the overhead sheet. Tell students to record the class data in Table 4-3. After all the data have been recorded, continue the class discussion by discussing the questions on The Idea Student Sheet. Add the term chlorophyll to describe the green pigment in the leaves of plants. Add the term photosynthesis as the process by which the making of food occurs. The students have not yet gathered all of the data to understand the equation for photosynthesis; therefore, a thorough discussion of this process is not included. An understanding of the process of photosynthesis requires formal reasoning.



INVESTIGATION #4: PRODUCERS

Name__________
Section_____Date_____

EXPANSION OF THE IDEA

Starchy Foods

1. Test each of the following substances with Lugol's iodine solution. Record your results by listing the color after testing.

Table 4-4

Substance Tested	Results	
	Positive	Negative
water		X
Starch Solution	X	
bean	X	
fish		X
chicken		X
rock		X
carrot	X	
potato	X	
cereal grain	X	

2. Which substances contain starch?

Answers will vary: bean, carrot, potato, cereal grain.

3. Which substances do not contain starch?

Answers will vary: water, fish, chicken, rock.

4. What group of organisms store starch?

plants

Ask students to bring several of the food samples previously listed. Add additional items if no enough are brought by students; you need a total of ten items. Insure that some of each variety (plant, animal, other) are used. You may need to prepare some of the foods before testing for starch. Cut the foods into small portions for easy distribution. Soak and scratch the surface of hard or waxy covered foods such as bean seeds to improve the absorption of iodine. Egg cartons or spot plates may help keep items separate.

During class discussion, record the results of the test on the blackboard or overhead and discuss the questions. Ask: the food made by producers is stored in which part of the organism: (seeds, fruits, roots); from what type of organism did the foods that do not contain starch come? (animals, NOTE: A third category of "Other" materials may be added). State that the animals cannot make their own food and are not "producers."

Optional: Carbon Dioxide and the Green Plant

Place filamentous algae or Anacharis in a stoppered test tube containing a solution of yellow-green Brom thymol blue (BTB) under direct light for a class period. Observe the change in color of the BTB solution to a blue color as caused by the plant absorption of carbon dioxide. Expand the concept from these data: Green plants use carbon dioxide.

You may have the students observe the bubbles being given off by the plants in the test tubes that were left in the light. Tell them that oxygen is produced during the process of photosynthesis.

INVESTIGATION #4: PRODUCERS

Name____________________
Section_____Date_____

EXPANSION OF THE IDEA

READING QUESTIONS: Death of a Producer

1. Which environmental variable killed the Elodea?

   the herbicide

2. Which environmental variable killed the fish?

   lack of oxygen

3. At what point did these environmental variables become "limiting factors"?

   When the herbicide killed enough Elodea, the oxygen content of the water decreased. When the fish did not obtain as much oxygen, they died.

4. A friend cleans out your aquarium and removes all of the soil and plants, leaving only the fish and water. Predict what will happen.

   The fish may die or return to the surface to obtain oxygen (different species have different oxygen level ranges).

5. A popular bumper sticker asks, "Have you thanked a green plant today?" Give two reasons for thanking a green plant.

   food production; oxygen production

6. Trace back the materials comprising the sticker and see whether the sticker itself represents an application of the slogan.

   The paper for the sticker comes from a plant.

TEACHER'S GUIDE

INVESTIGATIONS #5: FOOD CHAINS

EXPLORATION

Food Sources

CONCEPTUAL INVENTION (THE IDEA)

Food energy is passed from producers through a series of consumers forming a food chain.

EXPANSION OF THE IDEA

Rotten Food

Reading: Producers and Consumers

Optional: Eating for Survival

NOTE: Before beginning this investigation, set up the Exploration phase of Investigation #6; see Investigation #6 for details.

INVESTIGATION #5: FOOD CHAINS

INTRODUCTION

The concept of this investigation is: Food energy is passed from producers through a series of consumers forming a food chain. During the Exploration phase, the students observe a sequence of events which together form an aquatic food chain. From these observations, the concept is invented. Observations of the role of decomposers completes the food energy cycle. In the reading, the concept is expanded to include food webs and food pyramids. Appropriate audio-visual aids, such as Nova: Life on a Silken Thread, or Nature: The Rotten World Around Us, may provide further expansion of the concept.

The concept is expanded to include the following related content: Due to a variety of eating habits, food is passed between the organisms of several food chains forming a food web; the number of individuals available as food diminishes at each higher level of the food chain, forming a food pyramid; and, decomposers are organisms that break down dead organisms. The equipment you will need for this investigation follows.

EXPLORATION

Food Sources

NOTE: These organisms may be the same as those used for "Population Changes" in Investigation #6: Ecosystems

organisms for a simple,
  direct food chain (for example,
  algae-snails-crayfish or algae-
  water fleas-guppies-crayfish)
culture dish or aquarium
microscope
slides and coverslips
medicine dropper
small jar (beaker or baby
  food jar)

EXPANSION OF THE IDEA

Rotten Food

spoiled foods showing bacterial
  and fungal growths such as
  rotting vegetables, fruits, or
  cheeses (do not use bloody
  specimen)
hand lens or dissecting scopes
nutrient agar
petri dishes
grease pencil
innoculating loops
alcohol burners

Optional: Eating for Survival

magnifying lens and/or bug box
sweepnet or shake-container
  (box with clear plastic bag
  attached)
guidebook for organisms in your area
view chamber
plastic bags
forceps

INVESTIGATION 05: FOOD CHAINS

Name______________
Section____Date____

INTRODUCTION

Green plants are able to make their own food; but, where do animals get their food?

EXPLORATION

Food Sources

1. Observe the animals as directed by your teacher. Record your observations on Table 5-1.

Table 5-1

Organism	Feeding Observations

2. Which organisms eat only producers?

   Answers will vary.

3. Which organisms eat other animals?

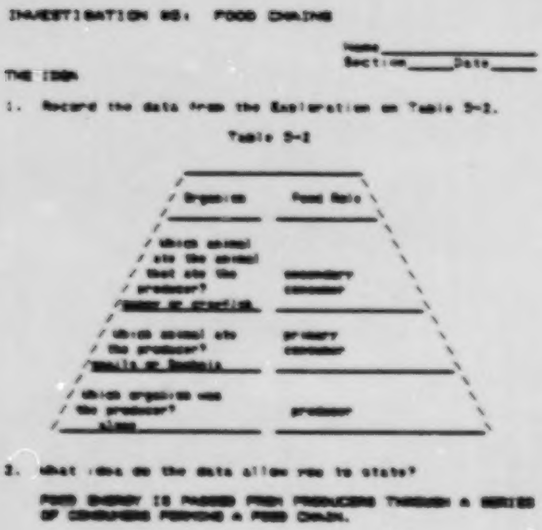
   Answers will vary.

The specific organisms used may vary. Several suggested sets of organisms are provided in the equipment list. When choosing the set of organisms for a food chain, keep the following in mind: organisms used should form a direct and observable food chain. Isolated cultures of each type of organism could be established several weeks in advance.

When feasible, allow the students to observe the organisms in their normal environment. If organisms must be moved when observing, allow a day for the organisms to adjust to their new environment. If the microscope is needed for this activity, allow the students two days to complete the training activity on the microscope (see Appendix--Microscope Skill Builder).

Several special techniques that may aid the students in their observations follow: crayfish should not be fed the week preceding this activity. Live or dead minnows may be used to feed the crayfish; snails may be added to an algae culture several days preceding this activity; and, *Daphnia* need to be transferred with a dropper. Count the *Daphnia* as they are added to the fish aquarium. Using a dissecting or projecting scope, microscopically observe the green algae in the digestive system of the *Daphnia* .

To enable the students to view the algae being eaten through a microscope, prepare the following: cut off the top of a 2-liter plastic bottle; add a 2-inch layer of sand to the bottom of the bottle; stand several microscope slides upright in the sand and add aquarium water, unicellular algae, and fertilizer. In a few weeks, algae growth will accumulate on the surface of the slides. Snails may be added to the set-up and snails can be inverted over a petri dish. Have the students wipe off the upper surface of the slide and place the dish and slide under the microscope. In this way, the student can observe snails feeding on the algae.



INVESTIGATION #5: FOOD CHAINS

Name________________

Section_____Date_____

THE IDEA

1. Record the data from the Exploration on Table 5-2.

Table 5-2

Organism	Food Role
Which animal ate the animal that ate the producer? guppy or crayfish	secondary consumer
Which animal ate the producer? Snails or Daphnia	primary consumer
Which organism was the producer? algae	producer

2. What idea do the data allow you to state?

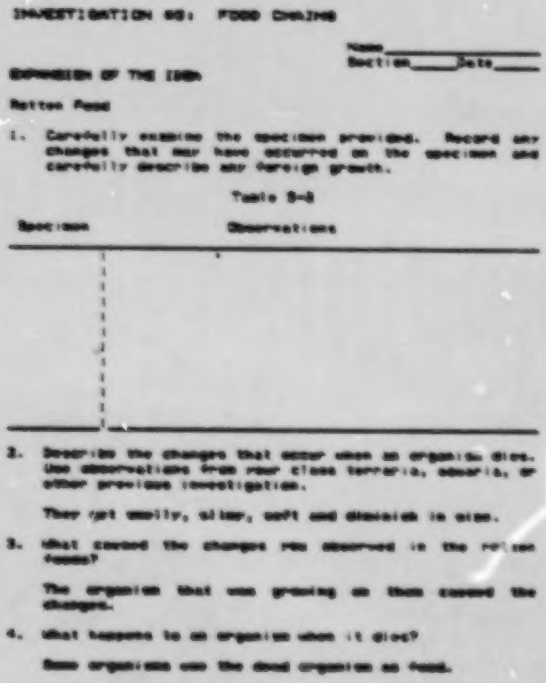
FOOD ENERGY IS PASSED FROM PRODUCERS THROUGH A SERIES OF CONSUMERS FORMING A FOOD CHAIN.

Pass out the Idea Sheet to the students. Ask them to share their data from the Exploration Phase and record it on a chart similar to Table 5-2 placed on the board or overhead projector.

Have students identify the producer in the Exploration activity and add the name of the organism to Table 5-2. Ask students to compare these organisms with producers. Add the word consumer in the food role column above the word "producer" on Table 5-2. Tell the students that the animals that eat the producers are called primary consumers. Add the word "primary" to consumers on Table 5-2. Add this organism to the appropriate place on Table 5-2. Tell the students that these animals are called secondary consumers. The top portion of Table 5-2 is open if you used any other organisms in the Exploration.

Ask students to draw arrows on their Table 5-2 to show the direction of the flow of food. Emphasize the dependence of each organism on the organism just below it in the food chain. A chain may be drawn on Table 5-2 to symbolize the links in the food chain supporting the load.

Add the terms herbivores, carnivores, and omnivores to the student observations. Identify the habitat in which the organisms the students observed during the Exploration Phase might live as aquatic or terrestrial. The habitat title may be added to the top of Table 5-2.



INVESTIGATION 6: FOOD CHAINS

Name______________
Section_____Date_____

EXPANSION OF THE IDEA

Rotten Food

1. Carefully examine the specimen provided. Record any changes that may have occurred on the specimen and carefully describe any foreign growth.

Table 6-2

Specimen	Observations

2. Describe the changes that occur when an organism dies. Use observations from your class terraria, aquaria, or other previous investigation.

   They get moldy, slimy, soft and diminish in size.

3. What caused the changes you observed in the rotten foods?

   The organism that was growing on them caused the changes.

4. What happens to an organism when it dies?

   Some organisms use the dead organism as food.

Several days before beginning this investigation, you will need to collect or have students collect, various foods showing evidence of decomposition, such as bread, cheese, fruit or wood. Plastic baggies may be used then thrown away.

You may have to remind the students of situations that have occurred during previous investigations or field trips. Tell the students that these organisms are bacteria and fungi. Ask them to compare the types of growths on each food source. Macroscopically distinguish between the slimy, shiny growth of bacteria and the fuzzy growth of fungi. Refer the students to their data on Table 6-2. These data may be displayed on a class chart similar to Table 6-2.

You may wish to have the students observe the fungi under a microscope. Bacterial colonies could be cultured on nutrient agar. Further, microbial studies should be avoided for the concrete student.

Tell the students that those organism are called decomposers; decomposers are organisms that use once-living matter as their food source. Have the students go back to The Idea Table 5-2 and draw arrows from the consumers to the producers, indicating the flow of food energy back to the producer.

The teacher may include additional discussion such as the one following: have the students write a paragraph defending their ideas about the following statement--Coyotes are vicious, blood-thirsty predators that kill and eat fluffy, defenseless little rabbits; therefore, they should all be killed.

Optional: Eating for Survival

Have the students collect damaged leaves of trees, shrubs, vines, or flowers from the study area. If the organism that did the damage can be found, collect it also. Have the students identify the food chains and food webs in their study area.

INVESTIGATION #5: FOOD CHAINS

Name____________________
Section_______Date_____

EXPANSION OF THE IDEA

Reading Questions: Producers and Consumers

1. What type of consumer are raccoons? omnivores Why are they placed into this category?

   Raccoons eat producers, herbivores, or other carnivores

2. Explain whether or not a single predator species (such as the raccoon) can be placed in more than one level of the food pyramid.

   The role of each predator in the food chain may change as the diet changes.

3. In what way is the ferret more specialized than the coyote?

   The ferret eats only prairie dogs, whereas the coyote can feed on a variety of organisms.

4. Why have many animals and plants become endangered?

   Animals: as the habitat of the food source is diminished, the populations decline. Plants: environmental variables change; the habitat is destroyed by the activities of man.

5. List two ways a predator (coyote) BENEFITS its prey (rabbit).

   Generally, the less-fit prey fall victim to predators; therefore, the more fit survive and reproduce. If predators are removed, the prey population becomes overcrowded creating conditions for disease and starvation.

INVESTIGATION #6: ECOSYSTEM

EXPLORATION

Population Changes

CONCEPTUAL INVENTION (THE IDEA)

Interacting populations and environmental variables form an ecosystem.

EXPANSION OF THE IDEA

Showdown

Problem: Lifestyles

Reading: Ecosystems in North America

NOTE: Population Changes must be prepared several weeks preceding this investigation.

INVESTIGATION #6: ECOSYSTEM

INTRODUCTION

The concept of this investigation is: interacting populations and environmental variables form an ecosystem.

In the Exploration phase, the students gather data from a microecosystem. Using data from the previous investigations and the microecosystem, the students will invent the concept.

In the Expansion phase, observations of additional organisms apply the concept. A short library search of an organism's niche will relate the concept to previous investigations. The reading will expand the concept to include biomes.

The concept is expanded to include the following related content: ecosystems are dynamic; consumer populations can affect producer population; a variety of interactions occur among populations; competition occurs between members of the same species and members of different species; and, every population has a role within the community. The equipment you will need for this investigation follows:

EXPLORATION

Population Changes

The setup for this activity should be done at least a week before you plan to begin the investigation.

Microecosystem Setup

aquarium jar
minnows or guppies
water plants
newts
Daphnia
snails

Optional

cover slips
thermometer
collecting jar & lid
dropper
microscope
rice, boiled
hay
slides
pond guide

EXPANSION OF THE IDEA

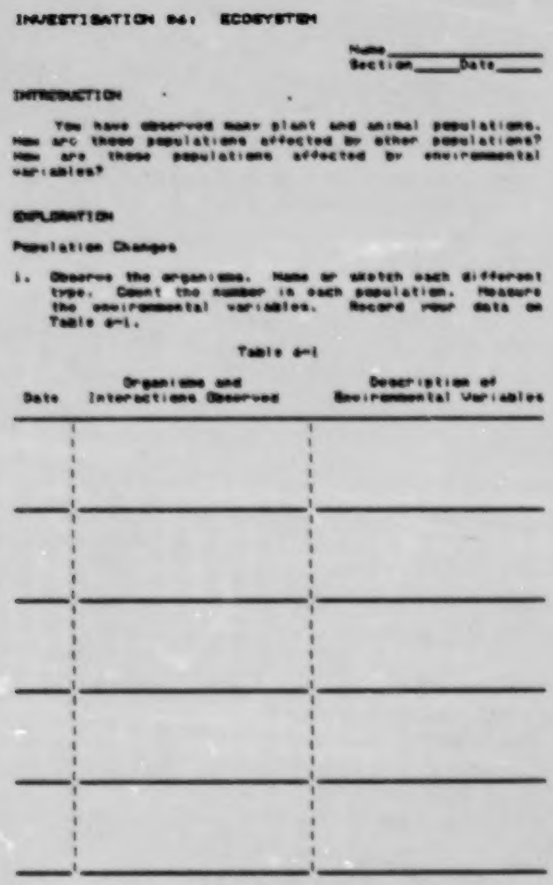
Showdown

Crayfish Setup

five crayfish
large plastic container
crayfish shelters (bricks with holes; flower pots; margarine tubs with holes)

Betta Setup

water plants
two male bettas
plastic or glass container



INVESTIGATION #6: ECOSYSTEM

Name____________
Section_____Date_____

INTRODUCTION

You have observed many plant and animal populations. How are these populations affected by other populations? How are these populations affected by environmental variables?

EXPLORATION

Population Changes

1. Observe the organisms. Name or sketch each different type. Count the number in each population. Measure the environmental variables. Record your data on Table 6-1.

Table 6-1

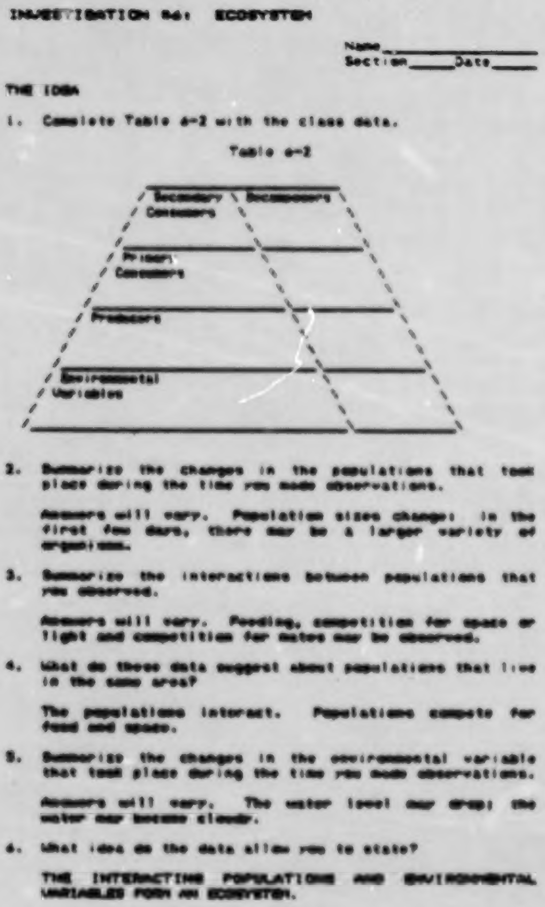
Date	Organisms and Interactions Observed	Description of Environmental Variables

The students observe changes and interaction in an aquarium for a few weeks. The aquarium should be set up during Investigation #5: Food Chains. An aquatic food chain, such as Elodea-> Daphnia-> guppies-> newts should be included. Ideally, the students should collect their own populations from a local pond or creek. You may wish to add a hay infusion to the microecosystem. To make a hay infusion, boil rice and hay. Add several grains of rice, a small amount of hay and about 50 ml. of the boiled hay infusion water to the aquarium set up. The hay infusion may be used for a discussion of succession in the Expansion Phase.

When making observations on the microecosystems, a specific procedure should be established. Each observation should include identification and counts of the different populations as well as measurements of the environmental variables.

Data from each observation should be included on Table 6-1. If the water is microscopically observed for protista, you may wish to provide an additional Table 6-1 and a simple pond water invertebrate guide. The sizes of these populations will vary in a shorter time.

Have the students collect data on the following environmental variables: water temperature; condition of the water (odor, clarity, depth); amount of light; and amount of air. You may wish groups to vary some of the environmental factors. If so, devise an appropriate procedure for each group to follow.



INVESTIGATION 6: ECOSYSTEM

Name________________
Section_____Date_____

THE IDEA

1. Complete Table 6-2 with the class data.

Table 6-2

Secondary Consumers
Decomposers
Primary Consumers
Producers
Environmental Variables

2. Summarize the changes in the populations that took place during the time you made observations.

   Answers will vary. Population sizes change: in the first few days, there may be a larger variety of organisms.

3. Summarize the interactions between populations that you observed.

   Answers will vary. Feeding, competition for space or light and competition for mates may be observed.

4. What do these data suggest about populations that live in the same area?

   The populations interact. Populations compete for food and space.

5. Summarize the changes in the environmental variable that took place during the time you made observations.

   Answers will vary. The water level may drop; the water may become cloudy.

6. What idea do the data allow you to state?

   THE INTERACTING POPULATIONS AND ENVIRONMENTAL VARIABLES FORM AN ECOSYSTEM.

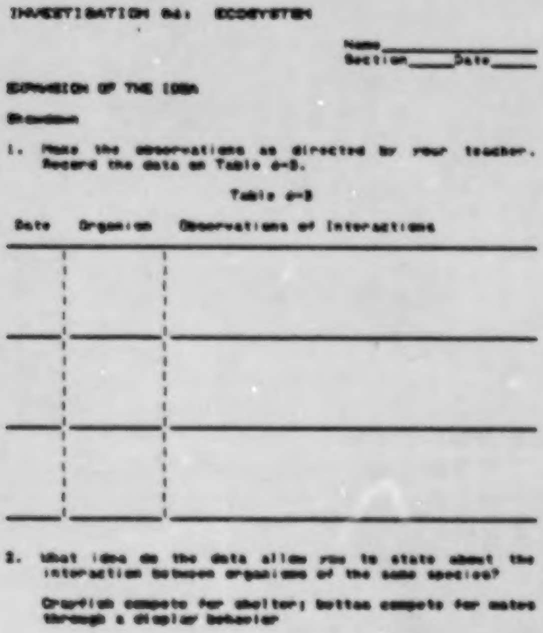
Before beginning discussion, pass out The Idea student sheet. Identify the populations that were present. Identification of the organisms is secondary to the interaction observations in this investigation. Add the term community to describe the interacting populations in a certain area. Add a list of each environmental variable mentioned. Ask the students to identify how each environmental variable might be a limiting factor in the interactions recorded. Refer students to Investigation One for these examples. Students should include water and shelter.

Ask the students to identify any examples in which a population served as a limiting factor. (Food as a limiting factor is the most obvious example. Producers, serving as shelter, may be mentioned.) Ask them to describe how the environmental variables in this area affect the populations of the area.

Identify the food chain and draw arrows showing the flow of food up through the food chain; identify the decomposers and draw arrows to show the flow of food to the decomposers; ask the students to identify the role of the decomposers; add minerals and nutrients to the environmental variables list, if they have not been identified previously, draw an arrow from the decomposers to those factors; and, review the concept that food energy materials are cycled through the community.

Ask the students if others of the environmental variables identified are cycled through the community. If the students offer the water cycle and/or any of the gas cycles, add these to the chart. If the students do not offer these, you can add them to the concept.

The teacher may wish to further develop the concept by expanding on the variety of interactions observed, e.g. interspecific and intraspecific competition for light, space, nutrients, water, mates, and territories. The specific interactions will vary according to the experiences in the classroom provided by the teacher. "Showdown" provides an example intraspecific competition.



INVESTIGATION [illegible]: ECOSYSTEM

Name____________
Section_____Date_____

EXPANSION OF THE IDEA

[illegible]

1. Make the observations as directed by your teacher. Record the data on Table [illegible].

Table [illegible]

Date	Organism	Observations of Interactions

2. What idea do the data allow you to state about the interaction between organisms of the same species?

Crayfish compete for shelter; bettas compete for mates through a display behavior

This experiment expands the concept to include examples of intraspecific competition. Either crayfish or male betta fish may be used. The instructions for each follow.

Crayfish: this activity requires at least one week to complete. After the initial set up time, only a few minutes per day are needed. To obtain crayfish, order medium-sized crayfish from a biological supply house; collect them from a pond, stream, muddy river, marsh, highway culverts, or other bodies of fresh water; or contact your state Fish and Game Department for assistance. Ask your students for help. The easiest way to catch a lot of crayfish is in a minnow trap or seine. A minnow trap is a wire or plastic cylinder with inverted funnels at each end. The crayfish walk into the holes in the bottoms of the funnels and usually cannot get out again.

Crayfish need to be kept in only enough water to cover their gills. They need to be placed and maintained in an area with plenty of oxygen within an hour or so after being collected.

To maintain crayfish, place in an aquarium, a gravel-lined wading pool, or a tote tray with one to two inches of cool water. (Do not use metal containers.) Be sure the sides of the tray are high enough to prevent their escape. If deep water is used, add an air bubbler. Adding Elodea may help maintain the oxygen level. The crayfish eat frozen or canned fish, snails, tadpoles, minnows, and algae. It might be best to have a separate plastic or glass feeding container to prevent fouling of the water.

The students may use natural markings on each crayfish or use a drop of airplane glue, nail polish, or felt pens to differentiate the crayfish. Use inverted margarine dishes or three-inch flower pots for crayfish homes. Cut a door for the crayfish and cut the bottom of the pot open and cover it with aluminum foil. This will enable students to observe the crayfish without disturbing it. Bricks with holes may be placed in a ten-gallon aquarium. The brick holes serve as crayfish homes that can be observed easily by students.

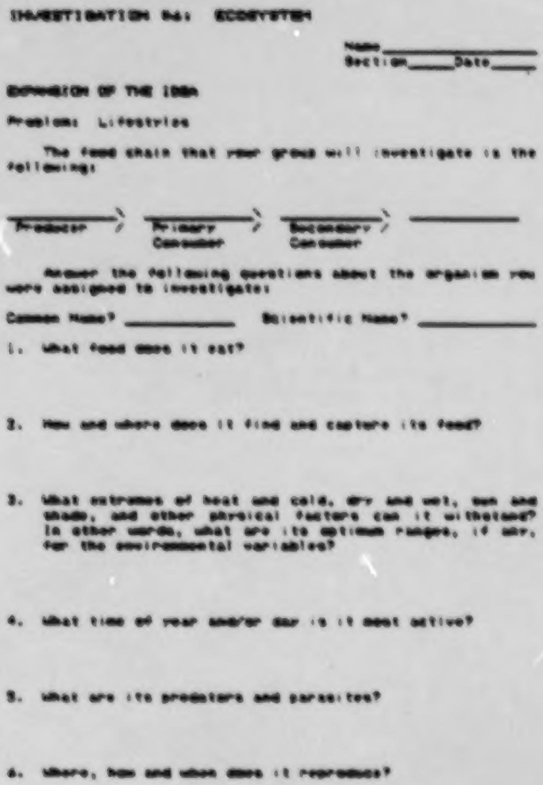
Set up crayfish pools for each group or for each classroom. Have students place five medium-sized crayfish of the same sex in one pool with five homes; place five medium-sized crayfish of the same sex in another pool with only one home. The teacher may wish to extend the observing days. Mixing the sexes may provide further observations for discussion.

Following is a sample procedure that the students might complete: place the marked crayfish in the pool. Each of the crayfish should be of the same sex. The number of houses should be one less than the number of crayfish. Each day have the students record the location of all the crayfish and evidence of any interaction that might take place between the crayfish.

Bettas: from a local pet store, obtain two healthy male bettas. Provide each with a glass pint jar of dechlorinated water and a sprig of Elodea. Square pint-size jars are optimal but round ones may be used. The rounded jars will magnify the image of each fish. Bettas may be fed regular fish food, e.g. Tetramin. Keep them out of sight of each other until needed. If kept close to one another they will accommodate to one another and not display. Do not put the bettas in the same jar, as they will injure or destroy one another.

Have each group observe the individual bettas. Discuss what observations they might make (color, position of tail and fins, movement, etc.). You may want to have several short observation times over a period of a few days. If you must use this pair for the next class, do not leave them together longer than necessary for the class to complete the observations.

After the initial observations have been completed, place the betta containers side by side. Ask the students to describe any changes. The bettas exhibit aggressive behavior, e.g., their gills flare up and they try to become as large as possible to exhibit dominance. They display rather than fight--and possibly get injured--to signal their male status in competing for a mate. This suggests a mechanism so that the most aggressive and strongest male will get to mate with any available females or the female can choose the best male. In class discussion, ask the students to share their data.



INVESTIGATION #4: ECOSYSTEM

Name_______________
Section_____Date_____

EXPANSION OF THE IDEA

Problem: Lifestyles

The food chain that your group will investigate is the following:

________ → ________ → ________ → ________
Producer   Primary Consumer   Secondary Consumer

Answer the following questions about the organism you were assigned to investigate:

Common Name? __________ Scientific Name? __________

1. What food does it eat?
2. How and where does it find and capture its food?
3. What extremes of heat and cold, dry and wet, sun and shade, and other physical factors can it withstand? In other words, what are its optimum ranges, if any, for the environmental variables?
4. What time of year and/or day is it most active?
5. What are its predators and parasites?
6. Where, how and when does it reproduce?

The teacher and/or students should select a simple, yet interesting, food chain that they have observed in their aquatic or terrestrial community. Have students record their food chain for future reference. NOTE: there is space if you wish to add a tertiary consumer.

Each member of the group will choose an organism from their chosen food chain. This activity can be restricted to completion of the student sheet or may be extended to a short written report. Students should be encouraged to obtain information from previous activities. Additional information will be needed. This could be a class trip to the school library or a homework assignment.

Prepare a transparency of the food web developed by the class. Ask the students to present the information, add any new organisms and interactions to the food web.

Suggest that every population has a certain role or job in a community. This role or job that they have described for each organism in a community is called the organism's niche. In short, every aspect of an organisms' existence helps to define its niche.

You may wish to have students review the reading from Food Chains and connect the idea that within a niche, some organisms are specialists (herbivores and carnivores) while other organisms are generalists (omnivores).

INVESTIGATION #6: ECOSYSTEM

Name____________________
Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: Ecosystems in North America

1. Explain how the environmental variables in a tundra and a desert are different.

   Water is the limiting factor in both. Temperature is much colder in the tundra, than the desert. Yet both biomes experience extreme fluctuations. Light varies in the biomes as well.

2. In what biome do you live? __**Answers will vary.**__

3. Give two examples of how an environmental variable affects: a plant population in your biome; an animal population in your biome.

   Answers will vary.

4. Give two examples of how an animal is adapted to live in extreme cold.

   Thick winter fur for insulation; hollow hair for insulation; body shapes reduce heat loss; color change with season; some animals dig under the snow, other migrate

5. Is the earth's climate warming or cooling? Scientists disagree as to what is occurring. One school of thought believes that as more particulate matter from the burning of fossil fuels is introduced into the air, the sunlight will be blocked from reaching the earth. This could cause a worldwide decrease in temperature. Could this be the signal of another Ice Age? However, climatological data kept over the past 100 years have shown a slow but steady increase in worldwide temperatures. If the earth is warming, predict the consequences for the following biomes: the tundra; your biome.

   tundra: the permafrost would melt, creating swampy conditions. As the polor ice caps melt, the lower areas might flood. The flooded areas could not support the plant growth. As the producers die, the entire food chain would be affected.

   your biome: Answers will vary. For example, in the temperate deciduous forest, the four seasons might continue, but conditions could become similar to those in the tropical rain forest.

INVESTIGATION #7: CELLS

EXPLORATION

Plants

Animals

CONCEPTUAL INVENTION (THE IDEA)

Organisms are composed of cells.

EXPANSION OF THE IDEA

Onion Cells

Elodea Cells

Reading: Units of Life

INVESTIGATION #7: CELLS

INTRODUCTION

The concept of this investigation is: Organisms are composed of cells.

Before beginning this investigation, the students must have mastered their microscope skills (see Microscope Skill Builder).

During the Exploration phase the students will observe and draw plant and animal cells. From these observations, the students will invent the concept.

Expansion of the concept allows the student to observe organelles. These observations expand the concept by showing that plant and animal cells have both common and unique structures. Following the experiments and discussion, the students will read about Robert Hooke and others who contributed to the study of cells.

Additional activities may be added to provide more time for accommodation of the concept. Observations of pond water shows that unicellular life exists. Slides of blood enable the student to develop the idea that different types of cells within an organism have different functions. If you choose to do the pond water activity, start the culture at the beginning of the learning cycle. Materials needed for the additional activities are not included in the materials list.

The concept is expanded to include the following related content: some characteristics are common to all cells; plant and animal cells have similar structures, yet have distinct differences; organelles within the cells enable them to carry on life processes; and, different groups of cells within an organism have different properties. The equipment you will need for this investigation follows:

EXPLORATION

Plants

microscope, slides,
  coverslips
forceps
plants: Coleus, Aloe Vera, lettuce, grasses, mushrooms

dropper
razor blades

Animals

microscope, slides,
coverslips
stain (iodine or methylene blue)
dropper
toothpicks

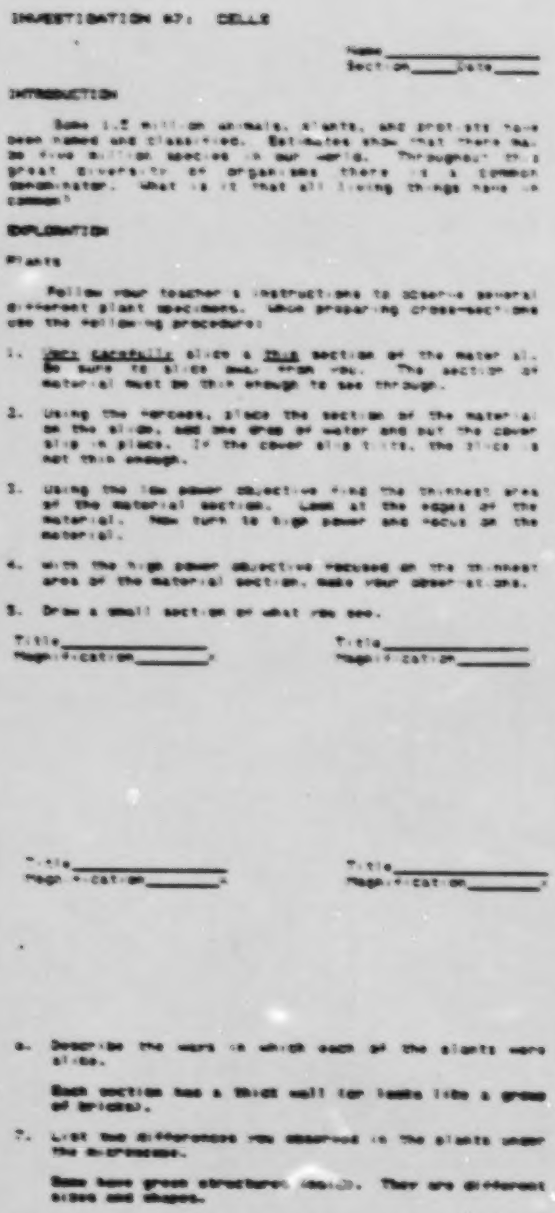
EXPANSION OF THE IDEA

Onion Cells

microscope, slides,
coverslips
stain (iodine or methylene blue)
onion
forceps

Elodea

microscope, slides,
coverslips
dropper
Anacharis *(Elodea)*



INVESTIGATION #7: CELLS

Name____________
Section_____Date_____

INTRODUCTION

Some 1.5 million animals, plants, and protists have been named and classified. Estimates show that there may be five million species in our world. Throughout this great diversity of organisms there is a common denominator. What is it that all living things have in common?

EXPLORATION

Plants

Follow your teacher's instructions to observe several different plant specimens. When preparing cross-sections use the following procedure:

1. Very carefully slice a thin section of the material. Be sure to slice away from you. The section of material must be thin enough to see through.
2. Using the forceps, place the section of the material on the slide, add one drop of water and put the cover slip in place. If the cover slip tilts, the slice is not thin enough.
3. Using the low power objective find the thinnest area of the material section. Look at the edges of the material. Now turn to high power and focus on the material.
4. With the high power objective focused on the thinnest area of the material section, make your observations.
5. Draw a small section of what you see.

Title____________ Title____________
Magnification________x Magnification________

Title____________ Title____________
Magnification________x Magnification________x

6. Describe the ways in which each of the plants were alike.

   Each section has a thick wall (or looks like a group of bricks).

7. List the differences you observed in the plants under the microscope.

   Some have green structures [illegible]. They are different sizes and shapes.

You may use a variety of plants. Include both green and non-green plants for the students to observe. The use of prepared slides at this point is discouraged. When preparing cross-sections, have students cut a very thin slice. Students may need help in getting the slice thin enough. You may wish to use a stain such as iodine on the cross-sections.

Encourage the students to include cell organelles in their drawings, but refrain from calling them by name unless the names arise from student conversations.

INVESTIGATION #7: CELLS

Name________________
Section_____Date_____

EXPLORATION

Animal

1. Place a drop of stain in the center of the slide. Stain used: Iodine or methylene blue.
2. Gently scrape the inside lining of your cheek with a toothpick. Use the large flat end of the toothpick. Mix the scraped material with the stain.
3. Add the cover slip.
4. Using the low power objective, locate the specimens.
5. Make drawings of at least two specimens under high power.

Cheek Cells　　Magnification_______.

6. Describe the specimens observed on this slide.

The specimens are irregular in shape, scattered and most have a small circle in the center.

Methylene blue or iodine may be used to stain the cheek cells. Demonstrate how to gently scrape cheek cells from the inside of your cheek with the flat edge of a toothpick. Cheek cells have a tendency to fold, placing the stain on the slide first and mixing the cells will keep this to a minimum. Assist the students in the making of a wet mount.

INVESTIGATION #7: CELLS

Name________________
Section_____Date_____

THE IDEA

Plant　　Animal

1. What did you observe in both the plant and animal specimens?

All had compartments, rooms, or boxes.

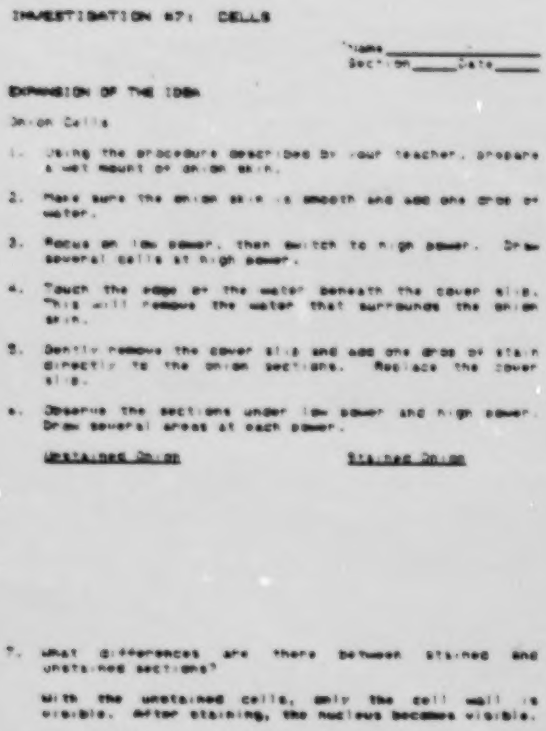
2. What idea do the data allow you to state?

ORGANISMS ARE COMPOSED OF CELLS.

Have the students refer to the Exploration student sheets and begin the comparison of plant and animal cells. Have students complete The Idea sheet as you discuss this with the class.

You may wish to have the students share their representative plant and animal cell drawings on the board. Allow them to agree on a composite drawing of representative plant and animal cells.

Wait until the Expansion for a discussion of organelles.



INVESTIGATION #7: CELLS

Name ____________
Section ____ Date ____

EXPANSION OF THE IDEA

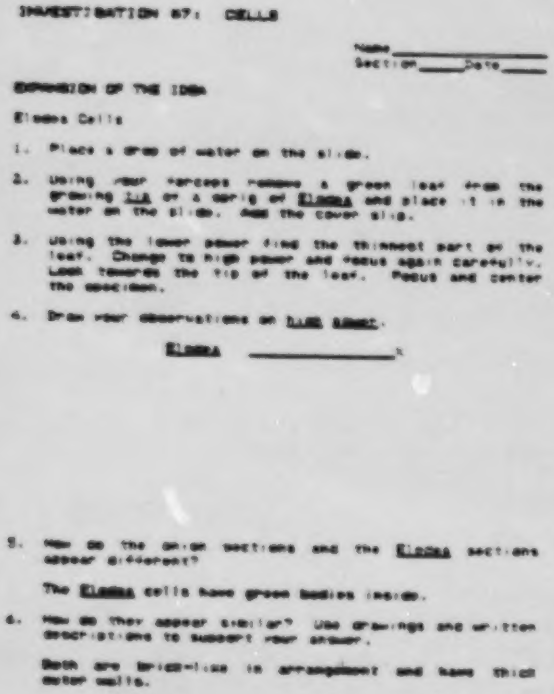
Onion Cells

1. Using the procedure described by your teacher, prepare a wet mount of onion skin.
2. Make sure the onion skin is smooth and add one drop of water.
3. Focus on low power, then switch to high power. Draw several cells at high power.
4. Touch the edge of the water beneath the cover slip. This will remove the water that surrounds the onion skin.
5. Gently remove the cover slip and add one drop of stain directly to the onion sections. Replace the cover slip.
6. Observe the sections under low power and high power. Draw several areas at each power.

Unstained Onion Stained Onion

7. What differences are there between stained and unstained sections?

   With the unstained cells, only the cell wall is visible. After staining, the nucleus becomes visible.



INVESTIGATION #7: CELLS

Name ____________
Section ____ Date ____

EXPANSION OF THE IDEA

Elodea Cells

1. Place a drop of water on the slide.
2. Using your forceps remove a green leaf from the growing tip of a sprig of Elodea and place it in the water on the slide. Add the cover slip.
3. Using the lower power find the thinnest part of the leaf. Change to high power and focus again carefully. Look towards the tip of the leaf. Focus and center the specimen.
4. Draw your observations on high power.

Elodea ____________x

5. How do the onion sections and the Elodea sections appear different?

   The Elodea cells have green bodies inside.

6. How do they appear similar? Use drawings and written descriptions to support your answer.

   Both are brick-like in arrangement and have thick outer walls.

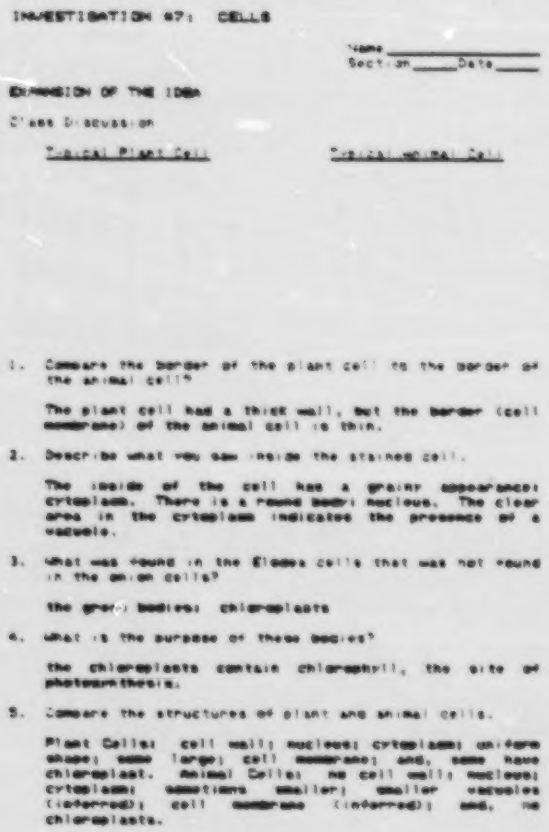
Use the following procedure to prepare the onion skins for wet mounts: slice the onion into quarter-inch sections; turn the concave side away from you; bend back a layer of onion to expose the thin epithelial layer. Explain to the students that only a small section is needed and caution the students about the stain.

Students may see a granular substance that leads to the assumption that something besides the nucleus is present inside the cell wall. Often the students can see the cytoplasm more easily under low power. Encourage the students to make their drawings large enough to show detail.

Do not discuss until students have completed the Elodea investigation.

Obtain Elodea (Anacharis) from a local pond or purchase at a local store. Rinse the Elodea thoroughly to remove foreign substances such as algae. Advise the students to pick a young leaf from the growing tip, avoiding brown, dying leaves. You may wish to suggest that students focus up and down with the fine adjustment to note the aspects of the three-dimensional Elodea cell. Using methylene blue, some students may be able to see the nucleus.

You may observe cyclosis in the Elodea. Cyclosis is not included in this cycle because it requires formal reasoning. You may wish to briefly explain this process to any interested student.



INVESTIGATION #7: CELLS

Name ____________________
Section _____ Date _____

EXPANSION OF THE IDEA

Class Discussion

Typical Plant Cell

Typical Animal Cell

1. Compare the border of the plant cell to the border of the animal cell?

   The plant cell had a thick wall, but the border (cell membrane) of the animal cell is thin.

2. Describe what you saw inside the stained cell.

   The inside of the cell has a grainy appearance: cytoplasm. There is a round body: nucleus. The clear area in the cytoplasm indicates the presence of a vacuole.

3. What was found in the Elodea cells that was not found in the onion cells?

   the green bodies: chloroplasts

4. What is the purpose of these bodies?

   the chloroplasts contain chlorophyll, the site of photosynthesis.

5. Compare the structures of plant and animal cells.

   Plant Cells: cell wall; nucleus; cytoplasm; uniform shape; some large; cell membrane; and, some have chloroplast. Animal Cells: no cell wall; nucleus; cytoplasm; sometimes smaller; smaller vacuoles (inferred); cell membrane (inferred); and, no chloroplasts.

Have the students refer to the data they collected in the Expansion phase. Ask different groups to draw both plant and animal cells on the chalkboard. Combine these drawings and have them draw a typical plant and animal cell. Label the drawings as you discuss the questions. You may want to discuss functions at this time, but limit this discussion to isolated bits of information, that is, because a cell has chloroplasts, photosynthesis is possible.

INVESTIGATION #7: CELLS

Name__________________

Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: Units of Life

1. Why did Robert Hooke use the term 'cell' to describe what he observed?

   The compartments he observed looked like those of a beehive. The beehive compartments are called cells.

2. Why has it taken over 200 years to discover most of the organelles?

   The instruments were not capable of magnifying the cells. Technology is increasing the data on the cell organelles.

3. Why can't organelles be considered as the basic unit of structure for living things?

   Organelles cannot live by themselves.

4. What three ideas make up the cell theory?

   1) cells are the unit of structure of all living things; 2) cells are the unit of function of all living things; and, 3) cells come from pre-existing cells.

5. Define a tissue. What different types of tissue would you expect to find in your thumb?

   A tissue is a group of specialized cells acting together to do a certain job: skin, blood, bone, cartilage, muscle.

INVESTIGATION #8: CELL TRANSPORT

EXPLORATION

Cell Membrane Model

CONCEPTUAL INVENTION (THE IDEA)

Some materials pass into and out of the cell while others do not.

EXPANSION OF THE IDEA

Osmosis

Reading: The Cell Membrane

INVESTIGATION #8: CELL TRANSPORT

INTRODUCTION

The concept for this investigation is: some materials pass into or out of the cell and other materials do not.

During the Exploration Phase the students will discuss diffusion and make observations that show that some but not all materials can move through a membrane.

The Expansion Phase visibly demonstrates osmosis with the osmometer and potato cores. The processes involved in the transport of materials across a membrane cannot be directly observed or experienced. The concrete student can understand the model but will have difficulty transferring the idea to the microscopic level of living cells. Extension of the concept to include differential pressures, Brownian movement, and other explanations requires formal thought and is discouraged. If you think the students need more activities to develop an understanding of diffusion, you may want to further demonstrate diffusion.

The reading expands the concept into the late formal operational understanding of cell membranes; therefore, you may wish to use it for enrichment only. Other suggested readings follow. Galston, Arthur W., "The Membrane Barrier," Natural History, August-September 1974. A discussion of the mechanisms used to move materials into the cell. This article is suggested for use as a teacher reference only, and "The Awesome Worlds Within a Cell," National Geographic, September 1976. A summary of the major organelles and how they are involved in performing the processes of life. Although several formal ideas are discussed, the article is written in an interesting and readable style.

Suggested demonstrations follow. LIQUID IN A LIQUID: slowly and carefully pour about 10 ml. of congo red or another available dye into a large beaker or jar of water; place a piece of white paper behind the beaker as you pour; and, leave overnight for further observations. SOLID IN A LIQUID: have students place a thin layer of a slightly soluble colored crystal in the bottom of a beaker; solids that are suitable include potassium permanganate ($KMnO_4$) and/or copper sulfate ($CuSO_4$); have students slowly and carefully add water to the side of the beaker; leave the set up overnight for further observations. SOLID IN A SOLID: have students place one inch of soil in a beaker or jar and carefully add a second inch of sand to the top; leave set up overnight; you may substitute other available materials, for example, vermiculite and gravel.

The concept is expanded to include the following related content: materials move by diffusion; cells have semipermeable membranes; various factors affect diffusion; and, osmosis is diffusion of water through a semipermeable membrane. The materials needed for this investigation are as follows.

EXPLORATION

Cell Membrane Model

- diffusion demonstration: scented aerosol, candle, incense, or ammonia
- dialysis tubing
- Bunsen burner, hot plate, or alcohol burner
- glucose solution
- starch solution
- Benedict's reagent
- Lugol's iodine solution
- string

EXPANSION OF THE IDEA

Osmosis

- Thistle tube or glass tubing
- molasses
- potatoes
- cork borers
- 15% sodium chloride (NaCl) solution
- rubber bands
- ring stands and clamps
- metric rulers
- eyedroppers
- dropper bottles

INVESTIGATION 8B: CELL TRANSPORT

Name________________
Section____Date_____

INTRODUCTION

Each cell must take in food and water. Cells also must dispose of waste materials made by the cell. How do these substances get into and out of the cell?

EXPLORATION

Cell Membrane Model

You have previously used Lugol's Iodine solution as an indicator for starch. In this activity you also will use an indicator solution called Benedict's Reagent which will show the presence or absence of sugar.

1. Place a dropperful of water in a labelled test tube. Add 10 drops of Benedict's Reagent to the test tube.

2. Place a dropperful of glucose (sugar) solution in a labelled test tube. Add 10 drops of Benedict's Reagent to the test tube.

3. Place the two labelled test tubes in a boiling water bath for 10-15 minutes. Record your results in the chart below.

Table 8-1

Material	Before Boiling	After Boiling
Water + Benedict's Reagent		
Glucose + Benedict's Reagent		

4. What color change indicates the presence of glucose?

The color changes from green to yellow to red to brown.

5. Fill one beaker with 100 ml. of water.

6. Obtain a piece of dialysis tubing. Rub it between your fingers or blow in the ends to open. Twist and tie the tubing securely at one end.

7. Fill the dialysis bag with 5 ml. glucose solution and 5 ml. starch solution. Twist and tie the other end securely. Rinse the outside of the tubing thoroughly.

8. Place the tubing into a beaker with 150 ml. of distilled water. Add 20 drops of Lugol's Iodine to the water in the beaker. Record observations on Table 8-2 at the start and after 15-20 minutes of the experiment.

Table 8-2

	Initial Observations		Observations After Waiting	
	Inside Tubing	Outside Tubing	Inside Tubing	Outside Tubing
Materials				

9. Complete Table 8-2 by testing the solution outside the dialysis tube with Benedict's solution. What does the test indicate?

The glucose from the tube is in the solution outside of the tube.

10. What color change took place inside the tube?

The starch turned purple or blue-black.

Diffusion demonstration: begin the demonstration by releasing the scented material at one end of the room. Ask the students to raise their hand when they detect the odor and to describe how strong or concentrated the odor is.

Ask where the concentration is highest and where it moves. This should help develop the idea that the materials move from an area of high concentration to areas of lower concentration and is called diffusion.

Time will be required to train the students to use the glucose indicator solution--Benedict's Reagent. The color change from green to yellow to red to brown indicates the presence of a simple sugar. Ask the students why they used the test tube containing water (as a control). You may want to do this as a demonstration.

To prepare for this activity, cut 20 cm. lengths of dialysis tubing and allow them to soak in water for at least fifteen minutes. Students may need to rub the ends or blow into the ends to open the tubing. The ten percent starch solution should be fresh and well mixed. To suspend the starch particles, the solution may be boiled.

INVESTIGATION #8: CELL TRANSPORT

Name ____________________
Subject ______ Date ______

THE IDEA

1. How can you detect the presence of the simple sugar glucose?

   Benedict's solution

2. What happened to the glucose that was in the dialysis tube?

   Glucose moved out of the tube.

3. What happened to the iodine solution outside the tube? What evidence do you have to support your answer?

   The iodine solution moved into the bag and reacted with the starch; the starch in the bag turned blue-black.

4. Summarize your answers on Table 8-1.

Table 8-1

What substances moved through the tubing?	What substances did not move?

5. What idea do the data allow you to state about the movement of materials across the cell membrane?

   SOME MATERIALS PASS INTO AND OUT OF THE CELL WHILE OTHERS DO NOT.

After discussing questions 1-4, ask the students how their observations could be explained by diffusion (a semipermeable membrane). You may wish to discuss the size of the molecule as the determining factor in this investigation. Ask students to offer a model of the cell membrane. The students are most likely to suggest that the membrane has pores of different sizes which enable materials to pass in and out.

Refer to the reading for the more current theories. Do not expect students to understand all the theories for cell membranes. Usually their suggested models will be surprisingly close to the simpler theoretical models, e.g., many will suggest that the membranes have pores; others will add that these pores are of different sizes to allow molecules to pass in and out; a few may suggest solubility or state of matter as variables that affect transport.

4. Obtain two beakers. Fill one beaker one-half full of distilled water and the other beaker one-half full of NaCl solution. Label each beaker. Use a cork borer to obtain two identical cylinders of potato. Measure the length of the cylinders at the start. Record their lengths in Table 8-5. Place a potato cylinder in each beaker. Allow the beaker and contents to stand for 15 minutes. Blot the cylinders dry, then measure the length of each and observe their stiffness and texture.

Table 8-5

Cylinder	Length at start	Length after 15 minutes	Stiffness and Texture after 15 minutes
potato in distilled H_2O			
potato in NaCl			

5. What happened to the length of the potato in the distilled water? NaCl solution?

increased; decreased

6. Compare the stiffness of the potato before placing it in the beaker with the texture and stiffness after treatment: distilled water; NaCl solution.

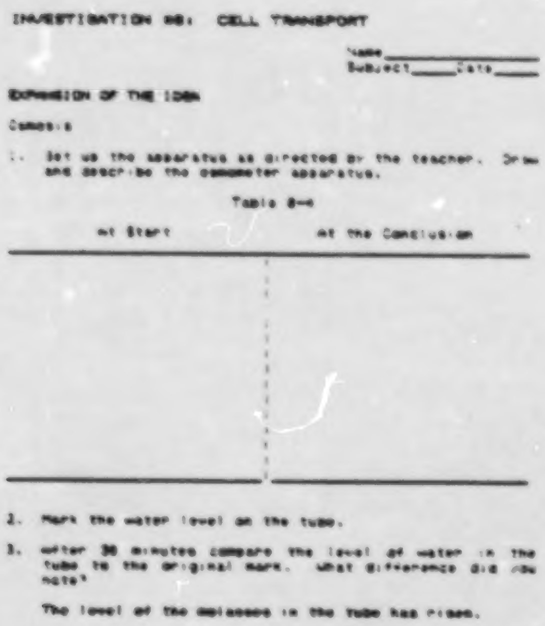
became stiffer; became limp

7. What do you think your data mean?

Water osmosed through the cell membranes of the potato.

Have the students set up or demonstrate an osmometer in one of the following ways: fill a thistle tube with molasses and seal it with dialysis tubing, mark the levels of the molasses and water, lower the tube into a beaker of distilled water and observe; fill a 10 cm. length of dialysis tubing with molasses, tie one end of this tubing with a string; fit the other end around a glass tube that is placed in a one-holed rubber stopper. Submerge the "baggie" in a beaker of distilled water, ask the students to predict the results and give reasons for their explanations.

Ask: What could have caused the increase? (water from the beaker going in from a high concentration to a low concentration). Did the molasses diffuse out? (no, but a little may have leaked out) Why? (focus on how the size of molecules affects the speed of diffusion) Since water diffused faster, it must have been small enough to pass through the artificial membrane. Diffusion of water is given a special name, osmosis.



INVESTIGATION #8: CELL TRANSPORT

Name________________
Subject_____Date_____

EXPANSION OF THE IDEA

Osmosis

1. Set up the apparatus as directed by the teacher. Draw and describe the osmometer apparatus.

Table 8-4

At Start	At the Conclusion

2. Mark the water level on the tube.
3. After 30 minutes compare the level of water in the tube to the original mark. What difference did you note?

   The level of the molasses in the tube has risen.

The student should use a cork borer to cut identical lengths of potato. The teacher should emphasize accuracy in measurement throughout this activity. Have students refer to Table 8-5 to compile class results. Compile and display the class data. Focus the students' attention on what must be causing the potato in water to enlarge. Explain that water is entering. This shows osmosis occurring, moving water from a high to a low concentration. Ask what is causing the potato in 15% NaCl to shrink? What must have left? (water osmosing in the opposite direction)

Further work can be done showing osmosis in living systems by placing red blood cells in a salt solution or by adding salt solution to a wet mount of Elodea. Both will cause observable changes to the living cells.

INVESTIGATION #8: CELL TRANSPORT

Name____________________

Subject_______Date_______

EXPANSION OF THE IDEA

Reading Questions: The Cell Membrane

1. What is a semi-permeable membrane?

   A membrane that allows some types of materials to pass through it, but not others.

2. Thousands of people living today must spend several hours each week hooked up to a kidney dialysis machine. The cells of a healthy kidney filter out many harmful substances which accumulate in the blood. If the cells of the kidney are unable to filter these substances, the person becomes seriously ill and may die. How does the kidney machine remove most of the harmful substances from the blood?

   Many of the harmful substances diffuse out of the blood into the kidney.

3. Describe how modern technology has increased our knowledge of cells.

   Chemical analysis and the electron microscope have aided in the identification of the materials that make up the membrane.

4. How does the membrane of a cell become more permeable to a substance?

   The arrangement of the proteins and lipids changes.

INVESTIGATION #9: CIRCULATION

EXPLORATION

Heart Sounds and Exercise

CONCEPTUAL INVENTION (THE IDEA)

Blood is pumped throughout an organism by the action of the heart.

EXPANSION OF THE CONCEPT

Fishtails

Blood Lab

Heart Dissection

Reading: Problems of the Heart

INVESTIGATION #9: CIRCULATION

EXPLORATION

Heart Sounds and Exercise

CONCEPTUAL INVENTION (THE IDEA)

Blood is pumped throughout an organism by the action of the heart.

EXPANSION OF THE IDEA

Fishtails

Blood Lab

Heart Dissection

Reading: Problems of the Heart

INVESTIGATION #9: CIRCULATION

INTRODUCTION

The concept of this investigation is: blood is pumped throughout an organism by the action of the heart.

During the Exploration phase, the students will observe the effects of exercise on their pulse rate. The idea that blood flows through blood vessels is illustrated by observing the flow of blood through a fishtail.

During the Expansion phase of the investigation, the students will examine a fresh heart and observe the action of valves as water flows through the heart. Blood samples will be examined to show its composition. The reading for this investigation introduces the student to some of the health aspects of the heart and circulatory system. The "Body Human: Red River," and Nova's "Portrait of a Killer" are excellent films for expansion of this investigation.

The idea may be expanded further by use of Daphnia to show beating hearts in small organisms. If equipment is available, allow the students to determine their own blood pressure.

Throughout the investigation, the emphasis should be on student observations. Structure and function relationships, pressure differentials, and ratios of volume to surface area of the body are formal concepts. It is suggested that these not be discussed at length during this investigation.

The concept is expanded to include the following related content: the heartbeat can be counted through the pulse or by using a stethoscope; the heart is a muscular organ through which blood flow is regulated; blood vessels carry blood throughout many animals; many factors affect the blood flow through an animal; and, heartbeat rates vary from person to person. The materials needed for this investigation are as follows.

EXPANSION OF THE IDEA

Fishtails

- goldfish or guppies
- microscope
- cheesecloth or cotton batting
- Petri dishes

EXPLORATION

Heart Sounds and Exercise

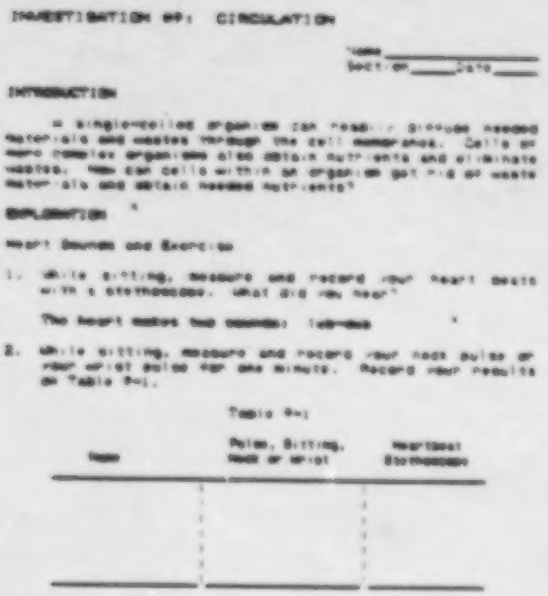
- stethoscope
- timer

Blood Stains

- slides
- blood lancets
- alcohol
- sterile cotton
- Wright's stain
- distilled water
- small bandaids
- centrifuge (optional)

Heart Dissection

- fresh mammalian hearts
- probes, glass or wood rods
- plastic bags for storing
- dissecting trays



INVESTIGATION #9: CIRCULATION

Name ________________
Section ____ Date ____

INTRODUCTION

A single-celled organism can readily diffuse needed materials and wastes through the cell membranes. Cells of more complex organisms also obtain nutrients and eliminate wastes. How can cells within an organism get rid of waste materials and obtain needed nutrients?

EXPLORATION

Heart Sounds and Exercise

1. While sitting, measure and record your heart beats with a stethoscope. What did you hear?

   The heart makes two sounds: lub-dub

2. While sitting, measure and record your neck pulse or your wrist pulse for one minute. Record your results on Table 9-1.

Table 9-1

Name	Pulse, Sitting, Neck or Wrist	Heartbeat Stethoscope

Illustrate the proper method for taking wrist and neck pulse. For wrist pulse have students use their middle finger to press gently on the thumb-side of the large tendon that runs along the forearm where the tendon meets the wrist. For neck pulse, have students locate their pulse by using their middle fingertip and pressing just below the lower corner of the jawbone under the ear. Have students practice locating and taking each others neck and wrist pulse. Students should count the pulse for one minute. You may wish them to count for fifteen seconds, then multiply by four to obtain the pulse rate/minutes.

Allow time for students to practice using the stethoscope. You may construct a stethoscope using a small funnel, three fifteen cm. lengths of rubber tubing and a y-shaped glass tube. Add a piece of tubing to each end of the Y-tube, then add the funnel to the bottom of the tubing on the shaft of the Y. The two free ends of the "stethoscope" will serve as ear pieces. When using either a regular stethoscope or a constructed one, provide cotton balls and alcohol for students to clean the ear pieces before each use. Instruct students to place the funnel or disk of the stethoscope against the left side of the chest near the midline. Encourage students to listen to the heartbeat of several people.

3. Exercise for at least 5 minutes or until you are breathing hard. Measure and record your neck pulse as soon as you stop exercising; 3 minutes after exercising; 9 minutes after exercising; 12 minutes after exercising. What happens to your heart rate after you exercise?

Table 9-2

Name	Neck Pulse (Sitting)	Minutes After Stopping Exercise				Recovery Time
		0	3	9	12	

Explain to the class that recovery time is the time it takes for their pulse rate to return to normal. Have students exercise by running in place for about five minutes. After exercising, have them sit down and record their heart rate immediately, then every three minutes until the heart rate returns and stays at normal (heart rates may drop below the average before stabilizing). It is helpful for discussion to categorize students such as athlete or non-athlete; girl or boy; smoker or non-smoker. You may wish to have the students graph their own recovery time and compare it to the class average recovery time.

Prepare an acetate sheet or large data chart for recording class data. Have students record their data on the class chart similar to Table 9-2. Use this table during the invention discussion.

INVESTIGATION #9: CIRCULATION

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Fishtails

1. Gently wrap a goldfish in a wet paper towel or cotton, but leave the tail uncovered. Place the fish in a petri dish. Wet the tail and the bottom of the dish. Add a few drops of water every two or three minutes to keep the tail moist. (Do not keep the fish out of the water longer than 5 minutes.)

2. Place the dish on the stage of the microscope so that the light passes through the thin tissue of the fish's tail. Using low power, observe the vessels in the fish's tail.

3. Compare and describe the rate of blood flow in several blood vessels.

   The rate of flow varies. The larger vessels have a higher rate of flow. The blood flows in different directions in different vessels.

4. Describe any differences you observe in the blood vessels.

   Some blood vessels are thinner than others; some blood vessels connect two blood vessels; blood runs in different directions in different blood vessels; some blood vessels carry more blood.

INVESTIGATION #9: CIRCULATION

Name________________
Section_____Date_____

THE IDEA

1. Calculate the class averages and record the data on Table 9-2.

Table 9-2

	Average Sitting Pulse	Average After Exercise Pulse	Range
Class	about 80		60-100
Boys	± 75		
Girls	± 80		

2. What variables might affect the heart rate?

   Exercise, excitement, health, gender or training may affect the heart rate.

3. What do the data allow you to state about the action of the heart?

   BLOOD IS PUMPED THROUGHOUT AN ANIMAL BY THE ACTION OF THE HEART.

Post a class chart and have the students calculate the class average heart rates. Group the student data by gender, smoking, athletic training, or size. Discuss the questions on the student sheet. Through a discussion of the data, expand the concept to include: when the heart is pumping, it is transporting nutrients and oxygen to the cells of the muscles so that jogging is possible; more nutrients and oxygen are used during jogging; and, the heart beats faster which supplies these nutrients and oxygen.

Caution the students to work quickly. The fish should not be out of the water more than five minutes. The loss of fish can be reduced by alternating the fish used each hour.

Whatever you use to cover the fish must be kept wet. Cotton sometimes sticks to the gills of the fish, so cheesecloth is recommended.

INVESTIGATION #7: CIRCULATION

Name_______________
Section_____Date_____

EXPANSION OF THE IDEA

Blood Stains

1. Obtain a drop of blood as described by your teacher. Place the drop of blood on one end of a clean slide.
2. Holding a second slide at a 45° angle, touch the edge of the drop of blood, then move the second slide across the top of the first slide. This will spread a thin film of blood over the surface of the slide.
3. Place the slide over a jar and add several drops of Wright's stain to the blood smear. Allow to stand for 2 minutes.
4. Using a medicine dropper, add enough drops of distilled water to rinse off most of the Wright's stain. Allow the slide to stand for 3 minutes.
5. Dip the slide in distilled water to remove any remaining stain.
6. Set the slide on a paper towel with the smear side up and allow the slide to dry. You may fan the slide to hasten drying.
7. When the slide is dry, observe the blood smear under low and high power magnification. Draw the different blood cells that you observe.

Blood Cells Magnification_______X

8. Which kind of blood cells are the most numerous?

The red blood cells are most numerous.

9. In what ways did the white blood cells appear different from the red blood cells?

The cells differ in size and in shape. The red blood cells are small and biconcave with no nucleus. The white blood cells are varied in shape.

10. Why do you think blood contains different kinds of cells and other substances?

Blood performs different functions.

Before this activity, review students on the necessity of sterile techniques when using blood lancets (disposable lancets are much preferred). The teacher may wish to lead the class step-by-step in the procedure.

Wright's stain substitutes may be Giemsa stain or other commercially prepared stains. If using Wright's stain, the red blood cells will appear pink after staining; the white blood cells will be blue because of their large, blue-stained nuclei.

You also may elect to fill several capillary tubes with blood, then seal the tubes with Cretoseal or a substitute such as clay. Immediately place in the centrifuge. Place the centrifuged samples so that the students can make their observations. The blood is separated into red and straw-colored sections. The plasma section will be greater than the red. You may want to discuss briefly the blood composition at this time.

Before beginning class discussion, have the students agree on a composite drawing of each type of cell that was observed. Students could be asked to list the observable characteristics of each type of cell.

INVESTIGATION #9: CIRCULATION

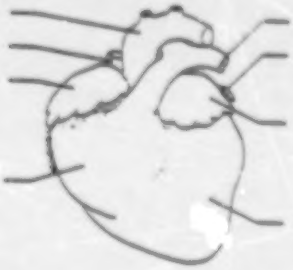
Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Heart Dissection

As the class discusses the heart, locate each part on the animal heart and label the drawing.

Figure 9-1



1. Position the animal heart as in Figure 9-1. The blood vessels enter the heart on the posterior side. Place the posterior side down with the narrow end (apex) pointing toward you.
2. Locate and examine the large blood vessels emerging from the top of the heart. These are the arteries and veins that carry blood to and from the heart. How is the tissue of the blood vessels different from the heart muscle?
3. Locate the ear-like flaps at the top of the heart. These are the atria, the upper chambers of the heart. The lower part of the heart consists of two chambers called ventricles.

USE HEART #1 PROVIDED BY THE TEACHER FOR THE FOLLOWING OBSERVATIONS. THE CHAMBERS ON THIS HEART HAVE BEEN OPENED.

4. As directed by your teacher, open the incisions, or make incisions to examine the atria and ventricles. Which are the largest of the chambers?

   The ventricles are the larger chambers.

5. Compare the thickness of the walls of the atria to the walls of the ventricles. Which has the thickest wall?

   The ventricles are thicker than the atria.

6. Compare the thickness of the walls of the ventricles. Which has the thickest walls?

   The left ventricle is thicker than the right.

7. Find the right ventricle. Run your finger or a probe upwards along the wall (septum) that separates the lower chambers. Where does the probe exit the heart?

   The probe exits through the pulmonary artery.

8. Find the left ventricle. Run your finger or a probe upwards along the septum. Where does the probe exit the heart?

   The probe exits through the aorta.

Obtain pig, sheep, or beef hearts from your local meat-packing company. Give them sufficient notice. Beef hearts are the least desireable because of their site and the amount of fat. The hearts may be refrigerated in plastic bags for several days.

Optimally, each student group should be provided with a heart for dissection. In this case, the bold print instructions on the student sheets should be omitted. If budgets do not allow you to provide one heart for each group in each class, the dissection is designed so that a minimum number of hearts can be used. The hearts may be used by each of your classes during the day. You will need two hearts per group. One that has been prepared for examination of the chambers and the path of blood through the heart and one with which the students can see how the valves function. It is suggested that the hearts be refrigerated after each use.

The hearts will need to be cleaned before beginning the lab. You can clean them yourself or the students can clean them during the first day activities. If the hearts have pieces of the lungs and trachea attached you may want to allow the students to make observations before they are cleaned.

Day one of this activity can be spent cleaning the hearts, labeling the heart diagram (Figure 9-1), and answering questions one through three. Restrict your discussion to the anatomy of the heart. The function of the valves and the path of the blood will be examined during the second part of the activity. If time permits, you may want to have the students label the internal structures of the heart in Figure 9-2.

RETURN THE HEART TO YOUR TEACHER AND EXCHANGE IT FOR HEART #2. THIS HEART HAS BEEN PREPARED SO THAT YOU CAN STUDY THE ACTION OF THE VALVES.

9. Find the right atrium and pull back the cut walls of the chamber. The three white flaps of material make up the auricular-ventricular (a-v) valve. Slowly pour water through the valve into the ventricle. What happens to the valve as the ventricle fills with water?

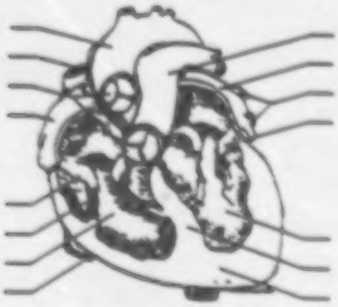
10. Find the aorta. It has been trimmed so that you can see three half-moon shaped flaps of tissue. These form the semilunar valve. Pour water into the left ventricle until the valve closes. Squeeze the left ventricle with a quick motion. What happens to the semilunar valve?

11. Gently pour water onto the semilunar valve. What happens to the valve?

12. What do your observations tell you about the function of the valves of the heart?

13. Use arrows to trace the flow of blood through the heart on Figure 9-2. Label the structures as the blood passes through the heart.

Figure 9-2



Preparing the Hearts for Examination: the atria of each of the hearts need to be opened; the right atrium can be opened by first removing the superior and inferior vena cava. Place your finger into one opening and out of the other and carefully cut along the finger; the left atrium should be cut at the same angle; make sure that the opening is large enough to allow the students to see the valves; take care not to destroy the valve; trim the aorta of each heart back so that the semilunar valves can be easily observed; leave enough of the aorta to enable it to be identified; one-half of the hearts need to be prepared so that the student may examine the internal structures of the heart and determine the path of blood through the heart; the incisions into the ventricles should be made on the posterior side of the heart; place a probe downward through the aorta into the left ventricle; make your incision from the bottom of the ventricle to within five centimeters of the aorta; the right ventricle can be opened by placing the probe into the pulmonary artery and following the same procedure for the incision; take care not to damage the semilunar and a-v valves with the probe or while cutting.

Many of your students will be hesitant to handle the heart. Probes and/or gloves (they will bring their own if you remind them) will help to prevent much of the problem.

INVESTIGATION #9: CIRCULATION

Name____________________
Date_____Section_____

EXPANSION OF THE IDEA

Reading Questions: Problems of the Heart

1. Describe a congenital heart defect.

   Blue babies are those that are born with an opening in the septum.

2. Why should parents not think of "strep-throat" as a minor illness?

   Rheumatic fever may result. Rheumatic fever may damage the a-v valves.

3. What methods are available for treatment of clogged coronary arteries?

   Drugs that dissolve blood clots; bypass surgery; inflatable balloon catheters; laser catheters.

4. What things can be done to reduce your chances of having problems of the heart?

   Heed warning signs, exercise, watch diet.

INVESTIGATION #10: CALORIES

EXPLORATION

Burning Foods

CONCEPTUAL INVENTION (THE IDEA)

Foods produce heat energy.

EXPANSION OF THE IDEA

Problem: Dieting

Problem: Calories in Action

Reading: Food, Glorious Food

Optional: Testing Foods

INVESTIGATION #10: CALORIES

INTRODUCTION

The concept for this investigation is: foods produce heat energy.

During the Exploration phase, the students will burn various foods and measure the change of temperature.

During the Expansion phase, the students will determine their daily caloric intake and compare this to the calories required for certain daily activities. The reading presents nutrition and the effects of nutritional deficiencies.

Further expansion of the concept can be achieved by conducting the optional activity: Testing Foods. The students should test various foods from their diet for carbohydrates, fats, and protein.

The content is expanded to include the following related content: carbohydrates, proteins, and fats are the three major types of food; carbohydrates include sugars and starches; as food is burned it provides heat energy called calories; different types of food provide different amounts of calories; a variety of physical activities requires different amounts of calorie intake; and, food energy is used by the body to provide energy. The materials needed for this investigation are as follows.

EXPLORATION

Burning Foods

foods: marshmallows and nuts
test tube clamps
flame source (Bunsen burner or alcohol burners)

test tubes
test tube racks
thermometer
dissecting needles

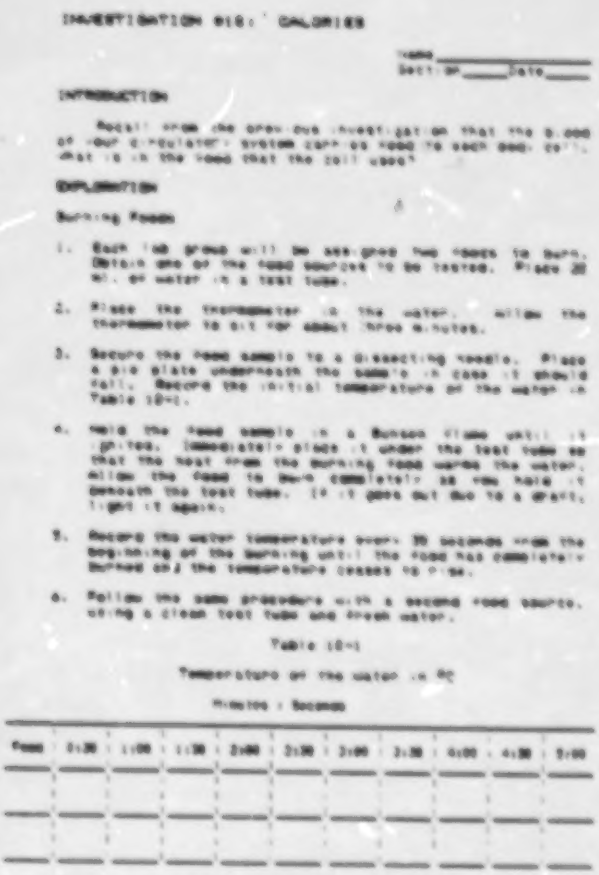
Problem: Dieting

calorie charts

Optional: Testing Foods

beakers
test tube clamps
eyedroppers
hot plates or Bunsen burners
brown paper bags (cut in strips)
10% sodium hydroxide (NaOH) solution
0.5% copper sulfate ($CuSO_4$) solution
egg white, 1:10 dilution
food samples (may be brought by students)

test tubes
test tube racks
dropper bottles
Lugol's iodine solution
Benedict's solution
0.5% glucose solution
1% starch
vegetable oil (liquid)



INVESTIGATION #10: CALORIES

Name________________

Section_____Date_____

INTRODUCTION

Recall from the previous investigation that the blood of your circulatory system carries food to each body cell. What is in the food that the cell uses?

EXPLORATION

Burning Foods

1. Each lab group will be assigned two foods to burn. Obtain one of the food sources to be tested. Place 20 ml. of water in a test tube.
2. Place the thermometer in the water. Allow the thermometer to sit for about three minutes.
3. Secure the food sample to a dissecting needle. Place a pie plate underneath the sample in case it should fall. Record the initial temperature of the water in Table 10-1.
4. Hold the food sample in a Bunsen flame until it ignites. Immediately place it under the test tube so that the heat from the burning food warms the water. Allow the food to burn completely as you hold it beneath the test tube. If it goes out due to a draft, light it again.
5. Record the water temperature every 30 seconds from the beginning of the burning until the food has completely burned and the temperature ceases to rise.
6. Follow the same procedure with a second food source, using a clean test tube and fresh water.

Table 10-1

Temperature of the water in °C

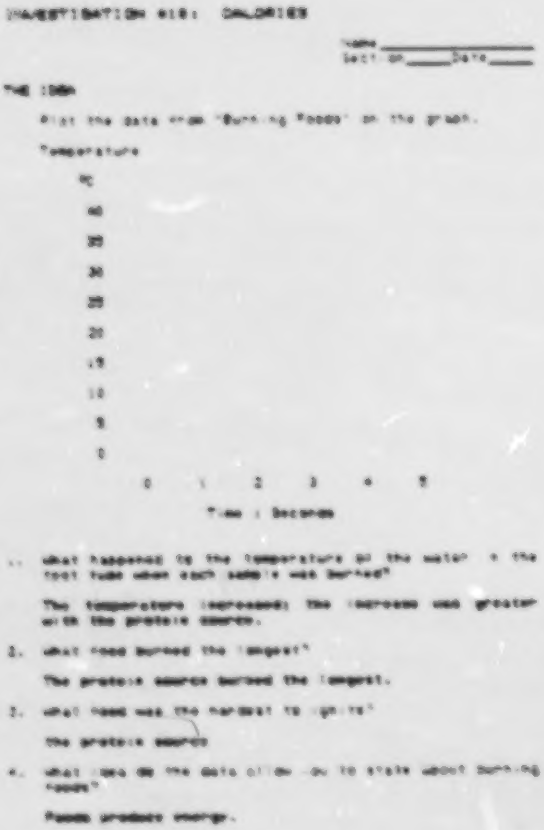
Minutes : Seconds

Food	0:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00

Marshmallows and pecans or peanuts are suggested food sources. A fat source such as butter or lard may be used, but is quite messy and dangerous to burn.

Caution students as to proper lab behavior and technique. They must observe the difficulty with which each food source is ignited, as well as the length of burning time and water temperature increases. Additional food samples may be provided, having students compare how long each takes to ignite. Each member of a group should have an assigned role in these activities, e.g., one burning the food, one reading the temperature, and one recording the data. Alcohol burners or Bunsen burners ignite the food samples easily, but should be used with extreme care. Hold the food samples with a dissecting needle and secure the test tube with a test tube clamp on a ring stand. A pie plate beneath will safely catch any falling samples of food. Caution your students on safety in this activity.

You may wish to have the students prepare a graph to aid them in interpreting their results. You may wish to graph the class data before proceeding.



INVESTIGATION #18: CALORIES

Name ________________
Section _____ Date _____

THE IDEA

Plot the data from "Burning Foods" on the graph.

Temperature

°C

40
35
30
25
20
15
10
5
0

0 1 2 3 4 5

Time : Seconds

1. What happened to the temperature of the water in the test tube when each sample was burned?

   The temperature increased; the increase was greater with the protein source.

2. What food burned the longest?

   The protein source burned the longest.

3. What food was the hardest to ignite?

   The protein source

4. What idea do the data allow you to state about burning foods?

   Foods produce energy.

Prepare a class graph and place it on the board or on the overhead. Collect the data from each group and ask the students to calculate the average temperature change for each food tested. Have the students plot their group data and the class average for each food tested. Ask the students to use the data to answer the questions on The Idea sheet. Ask: what evidence do you have for this? (heat was produced that warmed the water); do all foods have the same amount of energy, that is, did all foods heat the water the same? (no, return to the results for explanations).

The comparison of bond strength requires abstract reasoning and is not necessary at this point. However, if students ask, you may wish to relate bond structures in the following way: sugars are held together with a single embrace or by two people shaking hands; some fats, however, are held together by the people shaking both hands. The latter bond contains more energy, but also is harder to break. As a result, sugars will burn easier than fats, but will not release as much heat energy.

INVESTIGATION #10: CALORIES

Name____________
Sect. No._____ Date_____

EXPANSION OF THE IDEA

Problem: Dieting

1. Record the items that you eat for one day. Record the type of food present (i.e., protein, carbohydrate, fat) and the size of serving. If questions arise, make an educated guess as to food type. Use whatever sources your teacher provides to estimate the number of calories.

Table 10-2

Daily Diet Chart

Date: (Check Type of Food)

Food	Approximate Size of Helping	Approximate Number of Calories	Carbohydrate	Protein	Fat
Breakfast					
Lunch					
Dinner					
Snack					

2. What is your total calorie count for the day?

Answers will vary. The teenager's caloric intake is generally [illegible] kcal.

3. Explain whether or not you think your diet is balanced and why.

Answers will vary. A balanced diet consists of foods from each food group.

Table 10-3

Summary Chart for Class Data

Gender	Daily Calorie Count

4. Which foods contained the greatest number of calories?

Carbohydrates and fats generally contain the greatest number of calories.

5. Which foods contained the least number of calories?

Proteins generally contain the fewest.

6. Hypothesize: Which specific types of foods should you avoid when dieting?

Carbohydrates and fats should be limited in the diet.

7. Hypothesize: You are an athlete about to run the Boston Marathon. Which type of foods would you eat the day before the race? Why?

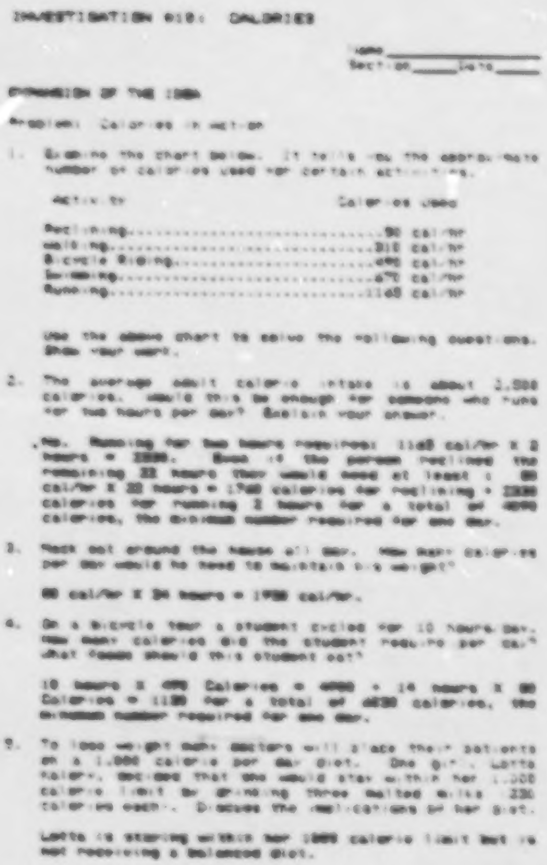
The weeks preceding the race, a protein-rich diet is best. In the days preceding the race, a high carbohydrate diet is best.

This sheet should be distributed several days prior to the class discussion (before burning foods). You may wish to have students record more than one day's diet. If so, duplicate as many student record sheets as necessary.

Instruct students to record what they ate, the approximate size of the helping, the approximate number of calories, and the type(s) of food contained in each. They may need some help in estimating the size of helping, the calorie count, and the type of food present. Since many foods contain more than one type, have them record whatever applies.

Good sources for calorie counts include popular cookbooks: The Joy of Cooking, Betty Crocker Cookbook, or Better Homes and Gardens Cookbook. An excellent source for the fast food restaurants was presented in Dietetic Currents, Volume 8, March 1981, published by Ross Laboratories, Columbus, Ohio, and reprinted by Redbook magazine, January 1982. Your home economics teachers also may have suggestions.

Have the students total their daily calorie count. (If students have recorded their diets over a three-day period, you may wish to average them before recording the data in a class chart). Record their data on a class chart similar to Table 10-3. Obtain class averages. You may wish to see if there are any differences between genders. Most teenagers require about 2,500 calories per day. Boys need slightly more; girls need slightly less. An adult construction worker needs about 3,500 calories per day. An athlete uses about 4,000 calories each day of the season.



INVESTIGATION #[illegible]: CALORIES

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Problem: Calories in action

1. Examine the chart below. It tells you the approximate number of calories used for certain activities.

Activity	Calories Used
Reclining	80 cal/hr
Walking	[illegible] cal/hr
Bicycle Riding	[illegible] cal/hr
Swimming	[illegible] cal/hr
Running	[illegible] cal/hr

Use the above chart to solve the following questions. Show your work.

2. The average adult calorie intake is about 2,000 calories. Would this be enough for someone who runs for two hours per day? Explain your answer.

No. Running for two hours requires: [illegible] cal/hr x 2 hours = [illegible]. Even if the person reclined the remaining 22 hours they would need at least: 80 cal/hr x 22 hours = 1760 calories for reclining + [illegible] calories for running 2 hours for a total of [illegible] calories, the minimum number required for one day.

3. Mack sat around the house all day. How many calories per day would he need to maintain his weight?

80 cal/hr x 24 hours = [illegible] cal/hr.

4. On a bicycle tour a student cycled for 10 hours/day. How many calories did the student require per day? What foods should this student eat?

10 hours x [illegible] Calories = [illegible] + 14 hours x 80 Calories = 1120 for a total of [illegible] calories, the minimum number required for one day.

5. To lose weight many doctors will place their patients on a 1,000 calorie per day diet. One girl, Lotta [illegible], decided that she would stay within her 1,000 calorie limit by drinking three malted milks ([illegible] calories each). Discuss the implications of her diet.

Lotta is staying within her 1000 calorie limit but is not receiving a balanced diet.

Have students examine the chart and answer the questions on the student sheet.

Optional: Testing Foods

Have students bring samples of a variety of foods to be tested. For convenience, the four tests are repeated here with some modification. Also, be sure to have students scratch the surface of any foods with waxy coatings, e.g., peanuts. SUGAR TEST: place each sample of food to be tested in a separate, numbered test tube; if the food is solid, it should be about 1 cm in size; any hard food, such as nuts, should be crushed using a mortar and pestle, and mixed in a little water (this also applies to the tests for starch and protein); put only water in one of the test tubes for a control; add 2-3 dropperfuls of Benedict's solution to each tube; place all the tubes in a beaker of boiling water for 3-4 minutes. STARCH TEST: number five or more test tubes from 1 to 5; place a sample of each food being tested for starch in a test tube or, if the sample is a solid, on a paper towel; scratch the surface of any solids; be sure to include a control; add one dropperful of iodine to each food. PROTEIN TEST: prepare a row of five test tubes; place a sample of each food to be tested for protein in a test tube; include a control; add two dropperfuls of 10% NaOH to each tube; next add one dropperful of 0.5% $CuSO_4$ to each tube. FAT TEST: spread the foods separately on a piece of brown wrapping paper; hold the paper up to the light and record which substances have translucent "grease spots"; moisture may result in false positives; allow paper time to dry.

INVESTIGATION #10: CALORIES

Name____________________
Section______Date______

EXPANSION OF THE IDEA

Reading Questions: Food, Glorious Food

1. In what metabolic processes are the nutrients from food used?

   energy, growth and repair, and to help regulate body processes

2. Dieting fads come and go. When choosing a diet, what should be considered?

   When choosing a diet, one's health should be considered. Foods should contain natural sugar and should contain representatives of each food group.

3. What are some ways that malnutrition can be corrected?

   more discoveries, such as development of FPC and algae farming

INVESTIGATION 6.1: DIGESTION

EXPLORATION

Food Tube

CONCEPTUAL INVENTION (THE IDEA)

Food must be digested to pass in and out of cells.

EXPANSION OF THE IDEA

Breakdown of Foods

Reading: Why Doesn't the Digestive System Digest Itself?

INVESTIGTION #11: DIGESTION

INTRODUCTION

The concept for this investigation is: Food must be digested to pass in and out of cells.

The Exploration phase allows the student to build and observe a model of the food tube. From this model, the concept is invented.

During the Expansion phase, the concept is broadened to include the different structures of the digestive system and the different jobs of each structure. The reading uses the language of the investigation and summarizes common disorders of the digestive system.

You could, as an optional activity, include a dissection of a frog to show the digestive system.

The concept is expanded to include the following related content: foods are absorbed by diffusion; digestion is the process whereby food is broken down from large food particles into small food particles; digestion occurs by mechanical means, such as chewing and peristalsis, and by chemical means through the action of enzymes; and, particular areas of the digestive system have specific roles in the digestion processes. The materials needed for this investigation are as follows.

EXPLORATION

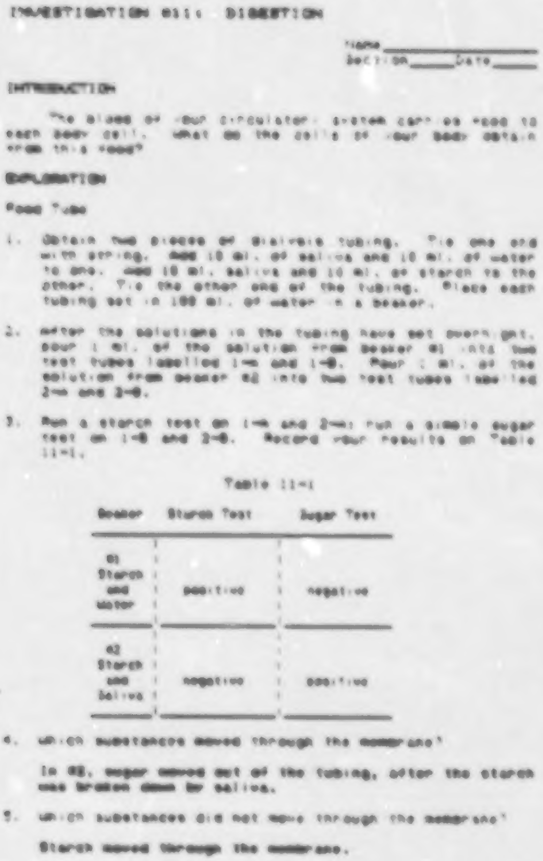
Food Tube

- dialysis tubing
- graduated cylinder
- Lugol's iodine solution
- Biuret reagent:
  - 10% sodium hydroxide solution
  - 0.5% copper sulfate solution
- string
- starch solution (boiled)
- Benedict's solution
- hot plate
- beakers
- test tubes

EXPANSION OF THE IDEA

Breakdown of Foods

- Stomach juice:
  - 1M HCl + 2 g. pepsin/100 ml. water
- Pancreatic fluid:
  - 2 g. of commercial pancreatin (the enzyme cleaner for soft contacts is pancreatin; dissolve one tablet in saline solution) and distilled water to make 100 ml. of fluid; add a pinch of sodium carbonate
- Protein: boiled eggwhite
- Carbohydrate: rice
- Fat: vegetable oil
- test tubes and stoppers
- test tube racks



INVESTIGATION #11: DIGESTION

Name_______________
Section_____Date_____

INTRODUCTION

The blood of your circulatory system carries food to each body cell. What do the cells of your body obtain from this food?

EXPLORATION

Food Tube

1. Obtain two pieces of dialysis tubing. Tie one end with string. Add 10 ml. of saliva and 10 ml. of water to one. Add 10 ml. saliva and 10 ml. of starch to the other. Tie the other end of the tubing. Place each tubing set in 100 ml. of water in a beaker.
2. After the solutions in the tubing have set overnight, pour 1 ml. of the solution from beaker #1 into two test tubes labelled 1-A and 1-B. Pour 1 ml. of the solution from beaker #2 into two test tubes labelled 2-A and 2-B.
3. Run a starch test on 1-A and 2-A; run a simple sugar test on 1-B and 2-B. Record your results on Table 11-1.

Table 11-1

Beaker	Starch Test	Sugar Test
#1 Starch and water	positive	negative
#2 Starch and Saliva	negative	positive

4. Which substances moved through the membrane?

   In #2, sugar moved out of the tubing, after the starch was broken down by saliva.

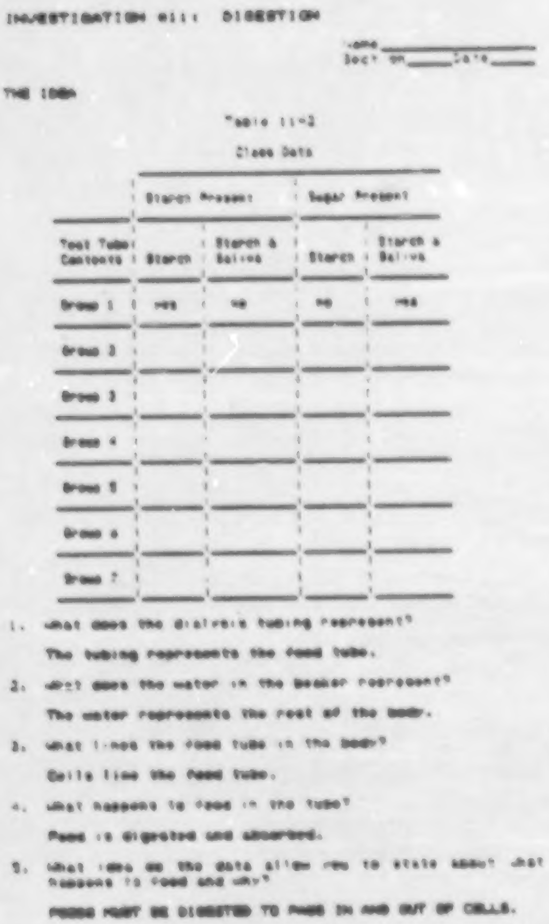
5. Which substances did not move through the membrane?

   Starch moved through the membrane.

Soak the dialysis tubing for at least thirty minutes. Prepare the dialysis tubing in one of the following ways: cut it in 4" lengths, tie both ends and immerse the entire bag in water; or, cut it in 6" to 8" strips, tie both ends, suspend the tube from a rod so that only the bag is immersed in the beaker and the ends are out of the water. This procedure imitates the digestive "tube."

Direct students to handle all solutions with caution. Clean up all spills immediately. Remind the students that the dialysis tubing forms an artificial membrane and we can measure the passage of substances through it using the appropriate indicator solutions.

Review the procedures for the starch test, the sugar test, and the protein test. Establish a definite procedure for this experiment before the students begin.



INVESTIGATION #11: DIGESTION

Name ____________
Section ____ Date ____

THE IDEA

Table 11-2

Class Data

	Starch Present		Sugar Present	
Test Tube Contents	Starch	Starch & Saliva	Starch	Starch & Saliva
Group 1	YES	NO	NO	YES
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				

1. What does the dialysis tubing represent?

   The tubing represents the food tube.

2. What does the water in the beaker represent?

   The water represents the rest of the body.

3. What lines the food tube in the body?

   Cells line the food tube.

4. What happens to food in the tube?

   Food is digested and absorbed.

5. What idea do the data allow you to state about what happens to food and why?

   FOODS MUST BE DIGESTED TO PASS IN AND OUT OF CELLS.

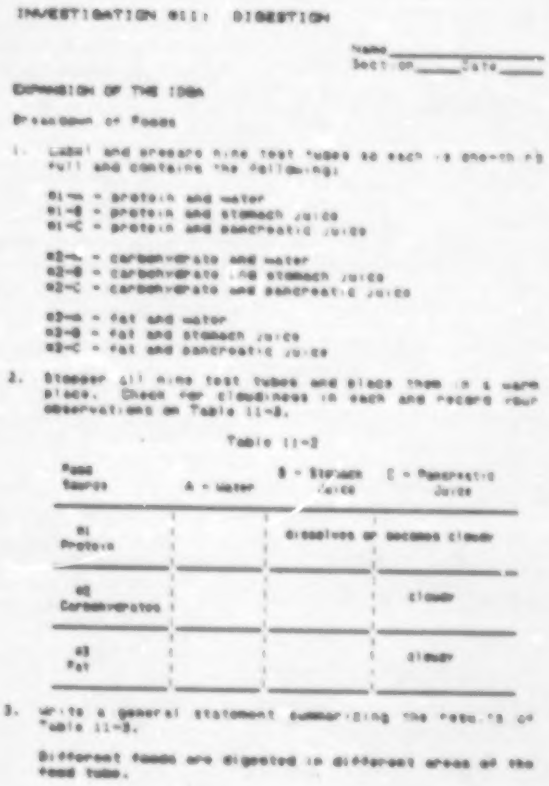
Refer the students to Table 11-1. Have them post these data on a Class Data Table 11-2 on the chalkboard or overhead projector. Ask the students to explain their results (something in the saliva changed the starch to sugar). Some of the students may identify the substance in saliva as a protein. Other possible ideas from previous investigations may be that the large molecule of starch was broken down into sugar, a smaller molecule. This may not be apparent to some students. Discuss the questions on The Idea sheet.

At this point, the teacher may wish to review the concepts developed in previous investigations regarding diffusion, osmosis and the properties of membranes. It is helpful to review the previously developed cell model. Ask the students to explain their results (starch, a large molecule, was broken down to glucose, a small molecule, which passed through the membrane).

Define digestion for the students: the process whereby food is broken down from large food particles to small food particles is known as digestion.

Ask students what happens to food once it is absorbed. Refer students to the calorie and that food is a source of energy for the rest of the body's activities. Postpone a discussion of aerobic respiration until Investigation #12. You may wish to expand on the types of digestion (mechanical and chemical) at this time.

Ask students what broke down or digested starch to sugar (the saliva, a protein in saliva). Tell students that chemicals (catalysts) which speed up the digestion process are known as enzymes. The concept of enzymes is abstract and the variables which affect enzyme action do not enhance this investigation on digestion. Therefore, it is left to the teacher to challenge more advanced students. You may continue by asking the students what else assists in the breakdown of food in the mouth (teeth, tongue). Tell them that these are examples of mechanical digestion.



INVESTIGATION #11: DIGESTION

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Breakdown of Foods

1. Label and prepare nine test tubes so each is one-[illegible] full and contains the following:

   #1-A = protein and water
   #1-B = protein and stomach juice
   #1-C = protein and pancreatic juice

   #2-A = carbohydrate and water
   #2-B = carbohydrate and stomach juice
   #2-C = carbohydrate and pancreatic juice

   #3-A = fat and water
   #3-B = fat and stomach juice
   #3-C = fat and pancreatic juice

2. Stopper all nine test tubes and place them in a warm place. Check for cloudiness in each and record your observations on Table 11-3.

Table 11-3

Food Source	A = Water	B = Stomach Juice	C = Pancreatic Juice
#1 Protein		dissolves or becomes cloudy	
#2 Carbohydrates			cloudy
#3 Fat			cloudy

3. Write a general statement summarizing the results of Table 11-3.

   Different foods are digested in different areas of the food tube.

Provide a source of food from each food group. Suggested ideas follow: protein--egg white; carbohydrate--rice, cracker, potato; fat--butter, margarine, vegetable oil.

It is recommended that you use the same food source throughout; although you may have students test a variety of foods.

Explain to the students that they will use commercially prepared solutions of stomach juices and pancreatic juices (normally found in the small intestine). After the students have prepared the test tubes, be sure to leave food sources to be digested in a warm area. An incubator set at 37° C is ideal. Stopper test tubes. If incubated, you will obtain results in one day; if not, 2-3 days may be necessary.

INVESTIGATION #11: DIGESTION

Name____________________
Section______Date______

EXPANSION OF THE IDEA

Reading Questions: Why Doesn't the Digestive System Digest Itself?

1. Describe how the stomach keeps from digesting itself.

   mucous lining, cell membranes and cell replacement

2. What causes ulcers?

   excess stomach acid, reduction in mucous lining, slow cell repair

3. What other major types of disorders of the digestive system occur?

   ulcers, gallstones, upset stomach, vomiting, diarrhea

4. Plan one day of balanced meals for a high school student with a lactose enzyme deficiency disorder.

Breakfast	Lunch	Dinner	Snacks

No milk or milk products, such as whey, cheese or cottage cheese. The students may need to check food box labels at home to answer the question.

INVESTIGATION #12: BREATHING

EXPLORATION

Bottled Organisms

Breathing Machine

CONCEPTUAL INVENTION (THE IDEA)

Animals exchange gases with the environment.

EXPANSION OF THE IDEA

Breathing Exercises

Demonstration: Smoking Machine

Reading: Keeping in Shape

INVESTIGATION #12: BREATHING

INTRODUCTION

The concept of this investigation is: animals exchange gases with the environment.

Using indicators, the students will test the gases taken in by and given off by organisms. By constructing a working model of the chest cavity, the students will observe how gases get into and out of the lungs. These observations will allow students an opportunity to assimilate the concept. After the conceptual invention, the structures of the respiratory system should be discussed. In this discussion, the structures and their functions should be treated as discrete bits of information, that is, because an animal has lungs, it can exchange gases. Only the early formal students can transfer the working lung model to the actual lungs.

In the Expansion phase, the effects of smoking on the lungs will be tested. Students will test the effects of exercise on breathing rate. They may compare those effects between athletes and non-athletes; smokers and non-smokers; girls and boys. From this exercise activity, the students will add the idea that "the exchange of gases provides air so food can be digested to produce energy." For the concrete student, this idea will be limited to a simple cause-and-effect relationship between respiration and energy production (refer back to the investigation on food groups and digestion). The reading will apply the concept to health issues. As an optional activity, the students may observe the lungs of a frog or fetal pig.

The concept is expanded to include the following related content: carbon dioxide is given off and oxygen is taken in during aerobic respiration; changing the size of the chest cavity allows for input and output of gases; smoking and exercise affect the respiratory system; and, the lung capacity of individuals varies. The materials you will need for this investigation follow.

EXPLORATION

Bottled Organisms

test tubes and stoppers
Bromthymol Blue solution
insects (mealworms or crickets)
cotton balls
dropper
Janus Green B

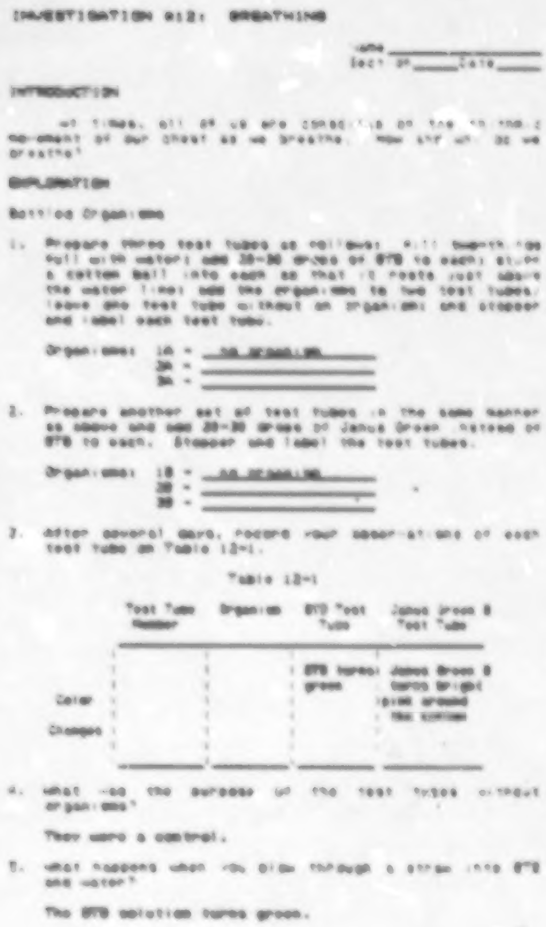
EXPANSION OF THE IDEA

Breathing Machine

- balloons
- two liter plastic cola bottles
- syringes (large) without needles
- sealer (candlewax, clay)
- corks and cork borers
- glass Y-tubes
- tubing
- rubber bands
- straws
- cellophane
- string
- baggies
- cotton

Smoking Machine

- Breathing machine (see above)
- cigarette
- cotton balls



INVESTIGATION #12: BREATHING

Name ______________
Sect # _____ Date _____

INTRODUCTION

At times, all of us are conscious of the in and out movement of our chest as we breathe. How and why do we breathe?

EXPLORATION

Bottled Organisms

1. Prepare three test tubes as follows: fill two-thirds full with water; add 20-30 drops of BTB to each; stuff a cotton ball into each so that it rests just above the water line; add the organisms to two test tubes; leave one test tube without an organism; and stopper and label each test tube.

   Organisms: 1A = no organism
   2A = ______
   3A = ______

2. Prepare another set of test tubes in the same manner as above and add 20-30 drops of Janus Green instead of BTB to each. Stopper and label the test tubes.

   Organisms: 1B = no organism
   2B = ______
   3B = ______

3. After several days, record your observations of each test tube on Table 12-1.

Table 12-1

	Test Tube Number	Organism	BTB Test Tube	Janus Green B Test Tube
Color Changes			BTB turns green	Janus Green B turns bright pink around the cotton

4. What was the purpose of the test tubes without organisms?

   They were a control.

5. What happens when you blow through a straw into BTB and water?

   The BTB solution turns green.

Provide at least one type of animal such as a mealworm or beetle with a small amount of food for each test setup. BTB should change to green after 24-48 hours, indicating the output of carbon dioxide. The teacher may wish each group to test different organisms to increase opportunities for assimilation.

In this experiment, use of Janus Green B (biological stain) is preferred to a methylene blue solution because it is more sensitive and more dramatic than methylene blue. To prepare the test tubes, add enough Janus Green B to the water in the test tubes to make a bright blue solution. After 48-72 hours, a bright pink color begins around the cotton, indicating the absence of oxygen in each test tube except the control.

If students previously have studied the CO_2 cycle, the BTB test may be omitted or different organisms should be used.

INVESTIGATION #17: BREATHING

Name______________
Section______Date______

EXPLORATION

Breathing Machine

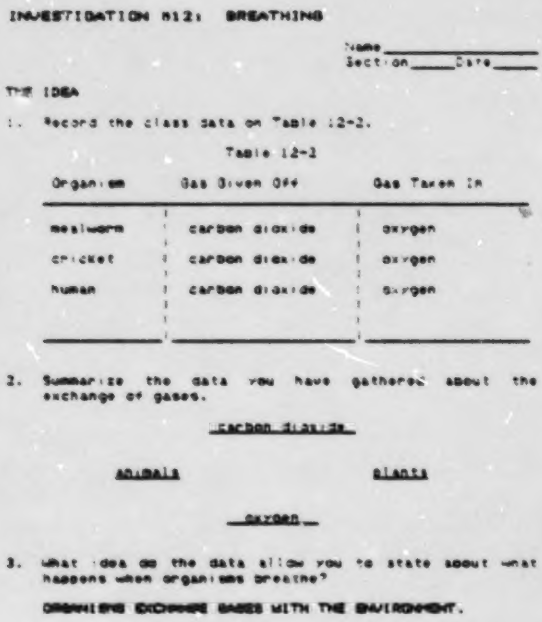
Describe and draw your "breathing machine" model.

You may make this activity a creative endeavor or give specific instructions for building chest models. For a creative endeavor, provide students with a variety of materials from which to create a working model of the respiratory system. You may need to ask leading questions to groups as they work: can you feel a change in the size of your chest cavity as you breathe; through which structures does air enter your lungs?

Several examples of models are included as follows.

Using a two liter plastic cola bottle, cut around the black bottom piece. Add a balloon or rubber piece around the bottom. Place a one-holed stopper in the small top opening. The stopper should have a piece of glass or plastic tubing (Y-tube works well) with baggies or balloons attached. Cotton may be placed inside the baggies for use in the smoking demonstration.

Using a gallon jar or a bell jar with a hole in the top, place a Y-shaped piece of tubing into a rubber stopper. Over the two pieces of tubing, place a plastic sandwich bag filled with cotton, secure with a rubber band, leave the single end of the tubing so that a cigarette may be placed into the opening during the smoking demonstration. Stretch a large balloon over the large opening and secure this with string or a large rubber band.



INVESTIGATION #12: BREATHING

Name__________________
Section_____Date_____

THE IDEA

1. Record the class data on Table 12-2.

Table 12-2

Organism	Gas Given Off	Gas Taken In
mealworm	carbon dioxide	oxygen
cricket	carbon dioxide	oxygen
human	carbon dioxide	oxygen

2. Summarize the data you have gathered about the exchange of gases.

carbon dioxide

animals plants

oxygen

3. What idea do the data allow you to state about what happens when organisms breathe?

ORGANISMS EXCHANGE GASES WITH THE ENVIRONMENT.

Pass out the Idea Sheet and ask the students to share their data as you post it on Table 12-2 displayed on the chalkboard or on an overhead projector. Ask the following questions: what process must each organism perform continually without even thinking about it? (breathe); what do they breathe out? (CO_2 gas); what do they breathe in? (O_2 gas); do other organisms exchange these gases? (yes) give your evidence (Janus Green B turned pink, BTB changed).

Ask the students how humans get air in and out of their bodies. Ask students to share their breathing models (the format of this discussion will vary with the format of your activity).

Ask the following questions.

What happens to the size of the "lungs" when the "diaphragm" is pulled in? (enlarge or expand.

What happens to the size of the "lungs" when the "diaphragm" is pushed in? (decrease or deflate).

When is air pushed out of the "chest cavity"? (when the diaphragm is pulled down).

How is the diaphragm pulled down? (muscle contraction).

Ask students to suppose they have a container of air which is suddenly increased in size, what would happen to the air pressure inside? (decrease).

What happens to the air pressure inside as the diaphragm contracts or is pulled down? (pressure decreases).

What happens when the pressure in the lungs is decreased? (air flows in).

When the diaphragm muscles relax what happens to the pressure inside the chest cavity? (it increases).

If students ask questions here, explain that the increase in pressure inside the chest cavity causes air to rush out because air pressure is less outside the chest cavity at this time.

Have students breathe deeply while feeling their chest, sides and back. Define the terms "inhale" and "exhale". Invent the concept through the use of the model, the idea of inspiration as brought about by the diaphragm and accompanying muscles (intercostals) and expiration (as brought about by the relaxing of the diaphragm and accompanying muscles). Early formal students can apply diaphragm functions to pressure differentials in the lung model. Add the term respiration to the concept. You may wish to add that water vapor is given off during breathing. This may be shown concretely by having the students breathe on a cold mirror.

INVESTIGATION #12: BREATHING

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Breathing Exercises

1. Count and record the number of breaths you take for one minute.
2. Take a deep breath and hold it. Record the time that you were able to hold your breath. How did you feel?

   The chest muscles felt tight.
3. While sitting, place a paper bag tightly over your nose and mouth. Breathe into the bag for one minute, then remove the bag. Immediately, count and record the number of breaths you take for one minute. As soon as you finish counting, take a deep breath and hold it. Count and record the time you were able to hold your breath after breathing into the bag.
4. Jog in place for two minutes. Count and record the number of breaths you take during the second minute of running. Then hold your breath and record how long you were able to hold it.

Table 12-3

		Holding Breath	After Bag Breathing		After Running	
Name	Normal Breaths per Minute	Time	Breaths per Minute	Holding Breath	Breaths per Minute	Holding Breath
	About 16					
Class Av.						

5. Choose one variable among students in your class that might affect breating rate (for example, gender or athletic training, smoking). Compare data from the different groups.

   Answers will vary. For example, athletes can hold their breath longer than non-athletes.
6. What happens to your breathing rate when too much carbon dioxide builds up in the paper bag?

   When carbon dioxide builds up, the breathing rate increases or deeper breathing occurs.
7. List factors that might increase your breathing rate.

   The breathing rate may increase when being frightened, when ill or when in higher altitudes.
8. When do you think your breathing rate might decrease?

   The breathing rate might decrease while sleeping.

Caution students to limit bag breathing to the time suggested in this activity. Suggest an area for the students to jog such as around the school building or in place. Students should sit while they hold their breath. Students with asthma or any respiratory problem should be recorders or timekeepers for the group. After bag breathing, the rate may stay the same but the breaths will be deeper. The time they can hold their breath will decrease. After running, the rate will increase and time they can hold their breath will decrease.

Have students post their data on a class chart on an acetate sheet for the overhead or on the board. Ask them to indicate several of their characteristics by using symbols in place of names, if they wish. For example, girl (g) vs boy (b); athlete (A) vs non-athlete (NA); music student (M) vs listener (L); smoker (S) vs non-smoker (NS). Have students average the results for each group.

Expand the concept to include: the exchange of gases (as evidenced by breathing rate) provides air so that food can be broken down to produce energy (for exercise).

Demonstration: Smoking Machine

There are no student sheets for this activity. You may use the models made by the students or a larger model. Place cotton balls inside clear balloons or baggies. Place a lighted cigarette into the opening of the "lungs". Have the students watch as the cigarette is "smoked" by pulling out and relaxing the diaphragm.

During the class discussion, ask the students to:

compare the amount of smoke that enters the lungs with that which leaves (most stays); observe the color of the cotton within the plastic baggie "lungs" (they should begin to yellow); and, to name the gases that are produced from smoking (carbon monoxide and carbon dioxide). A discussion about air pollution may be added to this Expansion demonstration.

INVESTIGATION #12: BREATHING

Name ____________________
Section _____ Date _____

EXPANSION OF THE IDEA

Reading Questions: Keeping in Shape

1. What causes you to breathe rapidly after running?

   The athlete breathes more rapidly, bringing a fresh supply of oxygen to the muscle cells and eliminating the excess carbon dioxide.

2. Name three changes that occur in your body from a long term program of aerobic exercising.

   Answers may include lower resting pulse; a larger heart, a stronger heart; an increase in red blood cells; and an increase in alveolar capillaries.

3. What types of food would a training athlete need to eat and why?

   An athlete should eat carbohydrates for energy and proteins for muscle building.

4. Use the following formula to compute the minimum and maximum working heart rates to use as guidlines during an aerobic fitness class for a beneficial training effect to occur:

My Age is 20
My maximum target heart rate average is 220 - Age = 200
My resting heart rate is 70

Formula: 200 Maximum Target Heart Rate

(subtract) -70 Resting Heart Rate

130 Answer A

(Multiply Answer A by .60 and by .80 to determine your minimum working heart range)

Answer A 130 X .60 = 78 Answer B

Answer A 130 X .80 = 104 Answer C

(add your Resting Heart Rate to Answer B and to Answer C)

78 Answer B	+	70 Resting Heart Rate	=	148	Minimum Working Heart Rate	148
					Divide by 6 to obtain 10 second heart rate	24.6
104 Answer C	+	70 Resting Heart Rate	=	174	Minimum Working Heart Rate	174
					Divide by 6 to obtain 10 second heart rate	29

INVESTIGATION #13: RESPONSES

EXPLORATION

Knees and Eyes

Taste

CONCEPTUAL INVENTION (THE IDEA)

Animals receive and respond to stimuli from the environment.

EXPANSION OF THE IDEA

Balancing Act

Eye Tests

Reading: Animal Senses

Optional: Eye Dissection

INVESTIGATION #13: RESPONSES

INTRODUCTION

The concept for this investigation is: animals receive and respond to stimuli from the environment.

The Exploration phase provides activities which allow the students to observe responses to stimuli.

The Expansion phase demonstrates integration of the senses. As the primary source of sensory input, the eye is tested. A mammalian eye may be dissected.

The concept is expanded to include the following related content: a variety of receptors detect stimuli from the environment; structures which bring about a response are called effectors; reflex arcs enable animals to receive, interpret, and respond to stimuli from their environment; and, senses may work in cooperation with one another.

At the conclusion of this investigation, the teacher may wish to discuss the nervous system. An understanding of the nervous system involves many formal concepts, the teacher may use whatever textbook and audio-visual aids they have available to discuss the brain, the parts of the brain and their functions, and how a neuron works. Realize that most of your students have not had chemistry and will have difficulty on these topics. Concrete students cannot relate structure they cannot see to a function they cannot measure. However, student interest is high in this area, so you may wish to discuss biofeedback, right brain vs left brain, learning disabilities, epilepsy, or the effects of drugs and alcohol on the brain. The equipment needed for this investigation follows.

EXPLORATION

Knees and Eyes

penlight
reflex hammer
acetate sheet

Taste

5% NaCl solution
1% lemon solution
5% sucrose solution
Q-tips

EXPANSION

Balancing Act

rope, 20′

Eye Tests

Snellen eye chart
colored tests
astigmatism chart

Optional: Eye Dissection

beef or pork eyes (fresh)
scissors or scalpels
dissecting trays
forceps

INVESTIGATION #13: RESPONSES

Name________________
Section_____Date_____

EXPLORATION

Taste

Place a clean Q-tip in the substances listed below. Taste each substance in the order listed. Rinse your mouth after each test.

As you test each substance, try to determine which area of the tongue registers the taste. Record your observations on Table 13-2.

Table 13-2

Substance	Location of Taste
Salt	
Sucrose	
Lemon	
Quinine	

You may wish to provide materials for each group or have a set of class equipment that can be passed from group to group. These activities can be done quickly. They serve to focus the attention of the student to their own responses to external stimuli.

INVESTIGATION #13: RESPONSES

Name________________
Section_____Date_____

INTRODUCTION

Crossing the street at a busy intersection can be very dangerous. To cross the intersection safely, you must receive information from your surroundings and decide when to cross the street. How do you receive the needed information?

EXPLORATION

Knees and Eyes

1. Sit down and cross your legs. Make sure the top leg is relaxed. Locate the kneecap of the top leg. Find the soft area just below the kneecap and just above the top of the leg bones. Use the side of your hand and strike this soft area below the kneecap. (Several attempts may be necessary before results are achieved. One strike and then a pause of several seconds is recommended before striking again.) Record your observations on Table 13-1.
2. Have your lab partner hold a sheet of clear material in front of his face. Crumple up a piece of scrap paper and toss it at his face. Carefully watch his eyes. Record your observations on Table 13-1.
3. Have your lab partner look directly into your face. Briefly shine a penlight directly into one of your partners eyes. You may need to repeat this several times. Record your observations on Table 13-1. Repeat the procedure, but this time observe what happens to the eye not exposed to the light. Record your observations on Table 13-1.

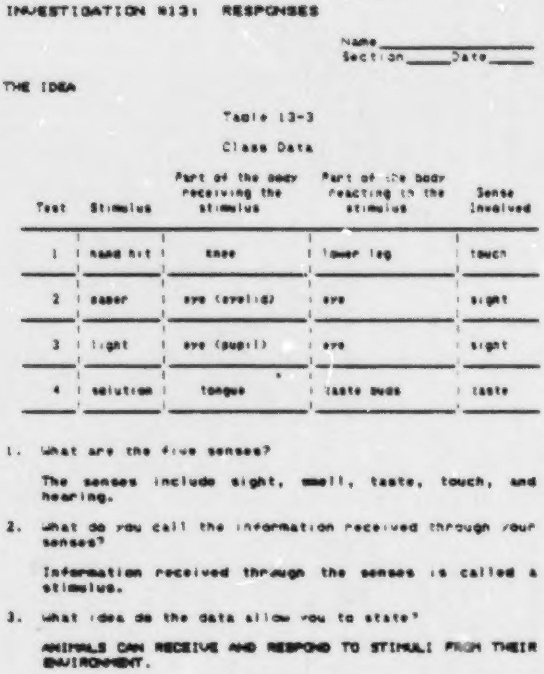
Table 13-1

Activity	Observations	
Knee Jerk	The top leg swings up when hit.	
Eye Toss	Both eyes blink.	
Light in the Eyes	Exposed Eye Pupil gets smaller.	Unexposed Eye Pupil gets smaller.

Have the students test each substance with a clean Q-tip. Allow them to rinse their mouths between "tastes". They must taste in the following order:

salt; sucrose; lemon juice; and, quinine, tonic water, or bitter coffee grounds (must be last or this substance will overpower all the others).

If your budget allows, have some mints available to eliminate the aftertaste which is very bitter.



INVESTIGATION #13: RESPONSES

Name________________
Section_____Date_____

THE IDEA

Table 13-3

Class Data

Test	Stimulus	Part of the body receiving the stimulus	Part of the body reacting to the stimulus	Sense Involved
1	hand hit	knee	lower leg	touch
2	paper	eye (eyelid)	eye	sight
3	light	eye (pupil)	eye	sight
4	solution	tongue	taste buds	taste

1. What are the five senses?

   The senses include sight, smell, taste, touch, and hearing.

2. What do you call the information received through your senses?

   Information received through the senses is called a stimulus.

3. What idea do the data allow you to state?

   ANIMALS CAN RECEIVE AND RESPOND TO STIMULI FROM THEIR ENVIRONMENT.

Hand out The Idea sheet. Refer to the Exploration sheets to complete Table 13-3. To introduce the central and peripheral nervous systems, ask the students if they had to think about the kneejerk or changing the size of the pupil? (no, both responses were automatic.) Tell the students that automatic responses to stimuli are called reflexes.

Suggest that there are several parts to a reflex action. The nerves that picked up the stimulus are part of the peripheral nervous system. When a stimulus is received, it may be transferred by sensory nerves so that it may be interpreted. The brain and the spinal cord are responsible for interpreting incoming information and sending out another message via motor nerves to perform a certain reaction. This pathway is the reflex arc.

Ask why it is necessary for the spinal cord to interpret messges. You may have to ask them how reflex actions are beneficial (the message must first pass through the spinal cord on its way to the brain, the faster the interpretation takes place, the sooner the response can take place; many reflex actions are protective mechanisms that help to prevent serious injury).

INVESTIGATION #13: RESPONSES

Name__________________
Section_____Date_____

EXPANSION OF THE IDEA

Balancing Act

Perform the following balancing acts with your eyes open then with your eyes closed: limit each act to sixty seconds.

	Eyes Open	Eyes Closed
1. Balance on one foot. How long could you stand?		
2. Balance on your other foot. How long could you stand?		
3. Balance with your right hand and right foot on the floor. How long could you balance?		
4. Walk on top of the rope with your shoes on. How far did you walk?		

5. Summarize the data you have gathered about balance and the sense of sight.

Sight is used to coordinate with balance.

Have the students compare their balance with their eyes opened and closed. Provide an eight to ten foot rope for #4. You may wish to perform this in the hall or outside your building on a sidewalk.

Balance is housed in the inner ear. Ask the students what would occur if we lost our sense of sight (senses work together, not separately; if we are deprived of one sense, the other senses can be trained instead; in the rope walk, the sense of touch will become important).

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INVESTIGATION #13: RESPONSES

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Eye Tests

1. Stand on the tape which is twenty feet away from the Snellen Eye Chart. Test one eye at a time with the other one covered. Record your test results below as to the last line readable. See the eye chart to record values.

Right Eye	Left Eye

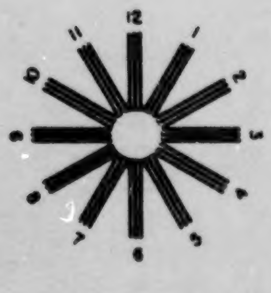
2. Focus on the letter x below.

Close one eye and move the page up to your eye until the letter becomes blurred; then move it away until you get a clear undistorted image. Have your lab partner measure the distance from your eye to the page with a ruler. The closest distance at which the eye can see a clear undistorted image is the near point. Test the other eye also and record your results below.

Name	Eye	Distance of Clearest Vision
Class Average		

3. Stand on the tape which is 10 feet from the pinwheel charts and test each eye individually. Are all lines sharp and equally black? If not, record the appropriate numbers:

Right Eye	Left Eye



These tests may be run before or after the eye disection. If only one set of classroom materials is available, have the students rotate from station to station so all of the activities can be completed. Discusion of the meaning of the test results will be more relevant to students after the dissection.

In the visual acuity test, if a student records 20/20 vision, this means that at twenty feet they can see what a normal eye can see at 20 feet. If a student records 20/200 vision, this means that at twenty feet, they can see what a normal eye can see at 20 feet.

The near point accommodation tests the ability of the eye lens to become thicker or thinner to focus on near or far objects. Near point increases with age varying dramatically after the age of forty. The teacher may wish to have students measure the near point for a variety of adults and graph the near point accommodation vs age. The lens becomes more inflexible as we age. From their dissection, they will be able to see that the lens is quite flexible and not at all hard like glass or plastic. Examine the class data to see trends. Ask the students to account for the differences. What part of the eye is sued to focus on close or far objects? (the lens); review observable characteristics of the lens (flexible, clear, softer at edges). Introduce that the lens is capable of accommodating, that is, changing it thickness to see close or far objects. The teacher may wish to have several glass or plastic lenses of various thicknesses to demonstrate that thick lenses focus clearly on near objects.

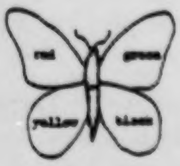
4. Evidence that a blind spot exists in each eye is demonstrated by using the test chart below.

+ ●

To test the right eye, one closes the left and stares at the plus sign with the right eye as the paper is slowly moved from about 18 inches toward the face. At first, both the plus and dot are seen simultaneously; but, at a certain distance from the eye, the dot will disappear as it comes into focus on the blind spot of the retina. Perform this test on both of your eyes. To test the left eye, it is necessary to look at the dot instead of the plus sign. Have your lab partner measure the distance from your eye to the test chart with a ruler. Record the measurements below.

Right Eye (cm)	Left Eye (cm)

5. Use colored pencils to color the labeled sections on the figure below. Stare at the dot in the center of the butterfly for one minute. Then stare at an unlined sheet of white paper. Observe the colors that you see in any afterimage. Describe the colors observed in the afterimage.



Ask students to view the size of a partner's pupil while looking at their paper. Then have them look at a far object across the room. The pupil is small (lens is thick) when focusing on a near object and vice versa. Therefore, we say that the lens is capable of accommodation.

In the Pinwheel Chart, if lines blur, darken, or thicken, what parts of the eye could cause a distortion in vision? (cornea and/or lens). This is called ASTIGMATISM and may be caused by a scratch or injury to these structures or irregular curvature of the cornea. The blind spot is difficult for many students to locate. At this point, you will need to veview the parts of the eye that light passes through from the eye dissection. The blind spot is the point where the optic nerve (sensory nerve) leaves the eye and has no receptor cells for vision. It is not directly at the back of the eye (the point of clearest vision) but slightly off center.

In the colored butterfly test, colors perceived in the afterimage are the opposite of the original, e.e., red is green, green is red, yellow is black (or blue), black is a light shade. The phenomena experienced is called retinal fatigue.

Optional: Eye Dissection

The eye dissection requires a fresh cow or pig eye. This activity will provide the student with information concerning the structure of the eye. During the dissection, guide the students as follows: examine the back and side surfaces of the eye, identify the optic nerve, look for the extrinsic muscles, only traces of these muscles will be present; note the shape of the pupil, is it round or elliptical? (depends on the eye), identify the cornea; holding the eyeball, make an incision into the scleroid coat with a sharp scalpel about one-quarter of an inch away from the cornea, note how difficult it is to penetrate, insert scissors into the incision and carefully cut all the way around the cornea, taking care not to squeeze the fluid out of the eye; gently lift the front portion off the eye and place it on the tray with the inner surface upward, the lens usually remains attached to the vitreous body, if the eye is preserved (not fresh), the lens may remain in the anterior part of the eye, with a dissecting needle, separate the lens from the vitreous body by working the needle around its perimeter, hold the lens up by its edge with a forceps and look through it at some distant object. What is unusual about the image seen? (upside down). Place the lens on printed matter. What does it do to the image? (magnifies it); looking at the inner surface of the anterior portion, identify the thickened, black circular ciliary body. Why do you think the pigment is black, why isn't it white or shiny? (black absorbs light); carefully examine the iris in your eyes, distinguish between the circular and radial muscle fibers. What is their function? (they help to open and close the pupil); and, compare the consistency of the lens at its center and near the edges (the edges are softer for flexibility).

INVESTIGATION #13: RESPONSES

Name____________________

Section______Date______

EXPANSION OF THE IDEA

Reading Questions: Animal Senses

1. While driving along a midwestern state highway on a sunny winter day, you see a red-tailed hawk perched on a fence post every few miles. Each hawk scans the grassland for a small rodent, reptile or bird. How is the hawk able to locate its prey as it sits perched on the fence?

   The hawk has binocular vision for depth perception and can pinpoint the location of the prey. Hawks can see 8X better than humans because the retina is tightly packed with light receptors, giving a sharper image.

2. Rabbit eyes are located on each side of the head. How might this vision be used to look for food and/or watch for enemies?

   Rabbits eat producers. There is no need for them to pinpoint the producers. While they eat, they need to look in all directions for predators. Eyes on both sides of the head allow this.

3. How does the hearing of owls differ from that of humans?

   The owl has ear openings at different levels on either side of the head. These result in"binocular hearing" and the owl can pinpoint sounds, whereas humans cannot.

4. What evidence is there that bird do not smell well?

   The Great Horned Owl preys upon skunks.

5. Give two examples to indicate the sense of touch being used by some animals.

   A cat uses its whiskers to determine the size of an opening; the woodpecker's tongue senses insects withing the holes of a treetrunk.

   A suggested reading related to this investigation is, "Wild Vision" by Roger Di Silvestro, Outdoor Oklahoma, September/October, 1982.

INVESTIGATION #14: LOCOMOTION

EXPLORATION

Wings and Arms

CONCEPTUAL INVENTION (THE IDEA)

Muscles and bones enable some animals to move.

EXPANSION OF THE IDEA

Bone Puzzles

Reading: Movement

INVESTIGATION #14: LOCOMOTION

INTRODUCTION

The concept for this investigation is: muscles and bones enable some animals to move.

During the Exploration phase the students examine the muscles and bones of a chicken wing. These observations are compared to the movement and structure of their own arm. The students then construct a working model of an arm.

The idea will be expanded as the student articulates several animal bones. The students will relate the movement of the joints of their body to animal joints.

The concept is expanded to include the following related content: bones give animals their structure and provide a place for attachment of muscles: muscles are capable of contracting; muscles work in opposing pairs; bones pivot at joints to allow movement; and, some joints are immovable. The equipment needed for this investigation follows.

EXPLORATION

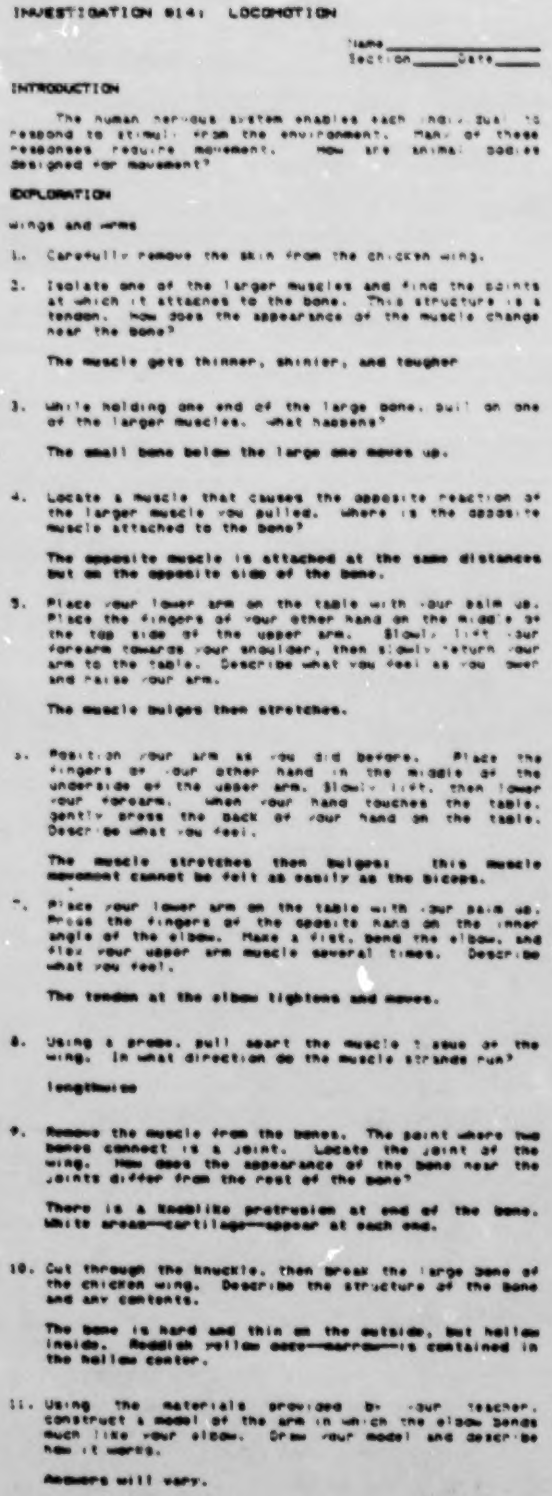
Wings and Arms

- dissecting kit and tray
- boards with eyehooks or rulers
- string
- chicken wings
- "hinge"

EXPANSION

Bone Puzzles

- various cow or horse bones or large animal or human skeletal model



INVESTIGATION #14: LOCOMOTION

Name__________________
Section_____Date_____

INTRODUCTION

The human nervous system enables each individual to respond to stimuli from the environment. Many of these responses require movement. How are animal bodies designed for movement?

EXPLORATION

Wings and Arms

1. Carefully remove the skin from the chicken wing.

2. Isolate one of the larger muscles and find the points at which it attaches to the bone. This structure is a tendon. How does the appearance of the muscle change near the bone?

   The muscle gets thinner, shinier, and tougher

3. While holding one end of the large bone, pull on one of the larger muscles. What happens?

   The small bone below the large one moves up.

4. Locate a muscle that causes the opposite reaction of the larger muscle you pulled. Where is the opposite muscle attached to the bone?

   The opposite muscle is attached at the same distances but on the opposite side of the bone.

5. Place your lower arm on the table with your palm up. Place the fingers of your other hand on the middle of the top side of the upper arm. Slowly lift your forearm towards your shoulder, then slowly return your arm to the table. Describe what you feel as you lower and raise your arm.

   The muscle bulges then stretches.

6. Position your arm as you did before. Place the fingers of your other hand in the middle of the underside of the upper arm. Slowly lift, then lower your forearm. When your hand touches the table, gently press the back of your hand on the table. Describe what you feel.

   The muscle stretches then bulges: this muscle movement cannot be felt as easily as the biceps.

7. Place your lower arm on the table with your palm up. Press the fingers of the opposite hand on the inner angle of the elbow. Make a fist, bend the elbow, and flex your upper arm muscle several times. Describe what you feel.

   The tendon at the elbow tightens and moves.

8. Using a probe, pull apart the muscle tissue of the wing. In what direction do the muscle strands run?

   lengthwise

9. Remove the muscle from the bones. The point where two bones connect is a joint. Locate the joint of the wing. How does the appearance of the bone near the joints differ from the rest of the bone?

   There is a knoblike protrusion at end of the bone. White areas—cartilage—appear at each end.

10. Cut through the knuckle, then break the large bone of the chicken wing. Describe the structure of the bone and any contents.

    The bone is hard and thin on the outside, but hollow inside. Reddish yellow ooze—marrow—is contained in the hollow center.

11. Using the materials provided by your teacher, construct a model of the arm in which the elbow bends much like your elbow. Draw your model and describe how it works.

    Answers will vary.

Chicken wings may be obtained from the grocery store. To insure a sufficient number of chicken wings, you may wish to contact the meat department several days before the wings are needed.

Circulate throughout the room during the dissection of the chicken wing. Some students may need help in pulling the muscles to move the wing bones. They should isolate the muscles to see the effects of pulling on each.

When asked to compare the movement of the chicken wing to the movement of their own arm the students may have difficulty observing movement of the tricep muscle.

Students may be directed by specific instructions in constructing a model or you may allow them to "invent" an arm. Two boards with several eyehooks screwed along one side for attachment of rubber strips or string will work well. Since most students have not observed the two bones in the lower arm, the use of one board to represent the forearm is acceptable. A hinge or other items such as tape may be used for a joint.

INVESTIGATION #14: LOCOMOTION

Name_________________
Section_____Date_____

EXPANSION OF THE IDEA

Bone Puzzles

1. Locate the following types of joints both on your body and among the bones provided by your teacher. Record your findings.

Table 14-1

Types of Joints	Locations on Your Body	Bone Groups
Moves all directions	shoulders hips	
Moves in one direction (and back)	knees elbows	
Moves only slightly	vertebrae	
Does not move	skull	

2. Describe the differences between the ends of the bones that make up each type of joint in Table 14-2.

Table 14-2

Moves all directions	
Moves in one direction	both hinge-like
Moves only slightly	both rounded
Does not move	jagged edge

INVESTIGATION #14: LOCOMOTION

Name_________________
Section_____Date_____

THE IDEA

1. What do bones do?

   Bones give support to the body and allow a place of attachment for muscles.

2. What do muscles do?

   Muscles contract and relax.

3. What do tendons do?

   Tendons attach muscles to bones.

4. What do ligaments do?

   Ligaments attach bones to bones at the joints.

5. Describe the arrangement of bones and cartilage in a joint.

   The bones are rounded and fit together for easy contact during movement.

6. Describe how muscles work in opposing pairs.

   One muscle contracts, while the other relaxes.

7. What idea do the data allow you to state about muscles and bones?

   MUSCLES AND BONES ENABLE SOME ANIMALS TO MOVE.

Pass out The Idea sheet and allow the students to discuss the questions. Guide them to invent the concept.

Obtain several groups of articulating bones. Bones from larger animals, such as horses and cows work well. Have students bring in bones or borrow the bones from a graduate school or museum. Kits are available. A human skeleton also could be used. Mark the bones using numbers, letters, or names so that students can record under 'Bone Groups' on Table 14-1 which ones they believe fit together at the various joints. You might wish to make this activity like a scavenger hunt or game in which the group that locates the most correct examples would receive some recognition.

After ample investigating, have students share their data from Table 14-2. Post the class data on a table on the board or acetate sheet. Add the names of each type of joint and the movements possible by each. An X-ray of joints and/or broken bones might add to this discussion. After the students have used examples of different articulated bones and determined the location of each, the teacher may wish to have students memorize some of the major bones in the human body.

INVESTIGATION #14: LOCOMOTION

Name____________________
Section______Date______

EXPANSION OF THE IDEA

Reading Questions: Movement

1. Describe an example that you have observed in which movement of an organism was a means of communication.

   The crayfish flapping of the tail and flaunting of the pinchers to frighten another crayfish; the Betta fish puffing around the gills and spreading its fins.

2. Describe the details of what occurs when you raise your arm.

   The nerve impulses from the brain travel to the flexor muscles of the arm, the muscle contracts, the bones pivot at the joints and the arm moves up.

3. What are differences between voluntary and involuntary movement?

   Voluntary muscles are ones that we can control, such as those in the arms and legs. Involuntary muscles relax and contract without our conscious control.

4. How do joints enhance movement? Give one example.

   Joints provide flexibility. For example, a ball and socket joint, such as the shoulder or hip joint, can move in a three-dimensional fashion. This is opposed to a hinge joint which can only move back and forth in the same plane. Examples of this are the elbow and knee joints.

5. How do the circulatory and respiratory systems work in conjunction to cause movement?

   The blood supplies the muscles with oxygen and food. Waste products are removed via the circulatory system. During exercise, the heart and lungs speed up their action to bring more food and oxygen to the muscles.

INVESTIGATION #15: CELL DIVISION

EXPLORATION

More Onion Cells

CONCEPTUAL INVENTION (THE IDEA)

New cells are produced by the process of mitosis.

EXPANSION OF THE IDEA

Large and Small Cells

Planaria

Reading: Carrots, Cloning, and Cancer

INVESTIGATION #15: CELL DIVISION

INTRODUCTION

The concept for this investigation is: new cells are produced by the process of mitosis.

During the Exploration phase, the students examine *Allium* root tip slides. After drawing the different phases of mitosis, the students view a filmloop showing cell division processes. From these observations, the students invent the concept.

In the Expansion phase, the students observe some of the results of cell division--regeneration and repair. The students will make observations as to how the size of the cell relates to materials entering the cell.

The concept is expanded to include the following related content: one cell divides equally into two new cells through the process of mitosis; cell division occurs in plants and animals; growth occurs by cell division, cell enlargement, and differentiation; cell size may be one of the factors affecting when a cell divides; and, simpler organisms and some parts of our body can regenerate new parts after injury. The materials needed for this investigation follow.

EXPLORATION

More Onion Cells

- green onion bulbs and/or prepared *Allium* slides
- slides, coverslips
- stain
- microscope
- scalpel

EXPANSION

Large and Small Cells

- agar
- sodium hydroxide
- metric ruler
- scalpel
- phenolphthalein
- paper towels
- beaker

Planaria

- planaria
- thin paintbrush
- slides
- petri dishes
- microscope or hand lens
- dropper

INVESTIGATION #15: CELL DIVISION

Name________________
Section_____Date_____

INTRODUCTION

Microscopic examination of organisms illustrate that each living thing is made of cells. Each cell of these organisms came from a pre-existing cell. How do existing cells produce new cells?

EXPLORATION

More Onion Cells

1. Each of the numbered microscopes around the room have been focused on one particular of the onion root specimen. DO NOT MOVE THE SPECIMEN! Observe and draw the cells in the spaces provided. Make your drawings large enough to show details of the structures within the cell.

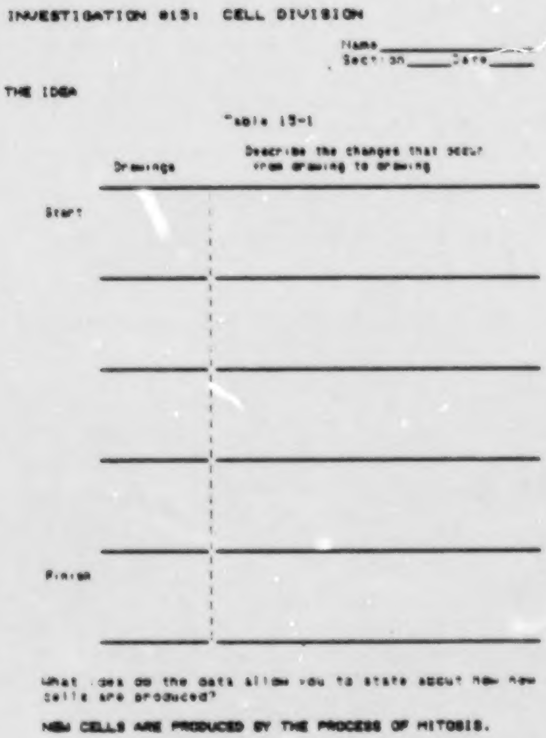
2. After you have completed the drawings of the cells, view the filmloop provided by your teacher. In your own words, describe what you see occurring. You may wish to add drawings of the process observed.

It is suggested that the students make their own slides. This will help the student to relate the prepared slides to the living organism. Immerse the roots of the onion bulbs in water several days before beginning the activity. Keep them in a dark area to prevent lignification. When the roots are two cm. in length, demonstrate the proper procedure to prepare a squash slide of the growing onion tip*.

Commercially prepared slides will usually be easier for the student to observe. Set up the numbered microscopes with the different phases illustrated in a sequence. Closely monitor the slides to make sure that they are not moved. If the microscopes do not have pointers, you will need to direct each group so that they will be able to make the needed observations.

If a filmloop projector is available, place it so that the students may view the mitosis filmloop when they have finished their observations. This approach allows students to view cell division as a continuous process from beginning to end. Use of the filmloop during invention of the concept is very useful. Suggested source: Mitosis-Animal and Plant: 8mm filmloop, color, Encyclopedia Britannica S 80073.

* To prepare the squash slide, cut a .2 cm. length from the root tip and place it on a slide. Soak the piece in HCl for several minutes, then heat (not boil) the acid on the slide. Soak up the acid with a paper towel and add one drop of toluidine blue O stain. After a minute or so, warm the slide again. Soak up the excess stain and add more stain and a coverslip. Wrap the slide in paper towelling and carefully press the coverslip with the eraser of a pencil.



INVESTIGATION #15: CELL DIVISION

Name________________
Section_____Date_____

THE IDEA

Table 15-1

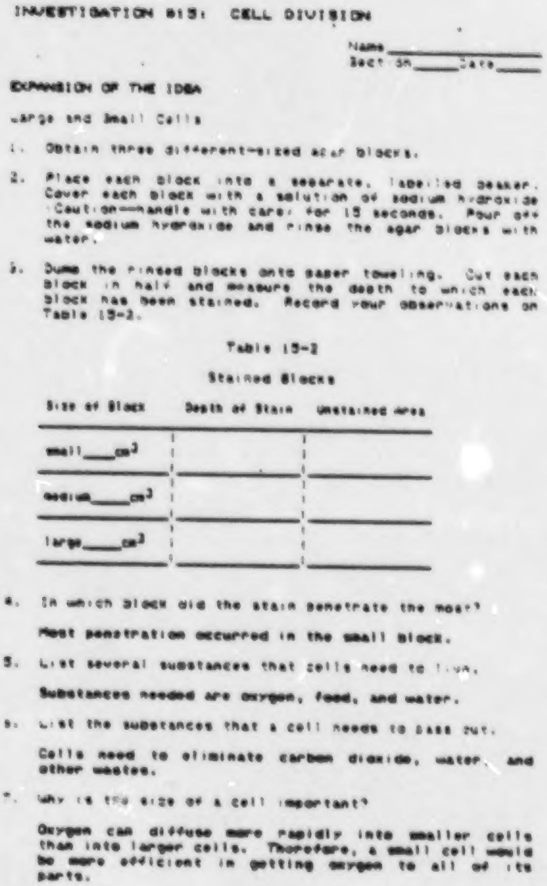
	Drawings	Describe the changes that occur from drawing to drawing
Start		
Finish		

What ideas do the data allow you to state about how new cells are produced?

NEW CELLS ARE PRODUCED BY THE PROCESS OF MITOSIS.

Begin the discussion by showing the mitosis filmloop. Have the students match the phases on the screen with their drawings. After they have matched their drawings to the filmloop, have the students describe what is occurring during each phase.

The teacher may wish to expand the concept at this point by continuing the model to show that this is an orderly process and results in an equal division of material. Point out that only one "parent" cell is involved. This cell divides, thus producing two new cells. This is known as asexual reproduction. If you wish to train students on how to identify the phases of mitosis and additional related vocabulary, do so at this time. It may help some of your students to view other slides of animal cells dividing (e.g., Ascaris, or fish eggs) to practice identifying the process in animal cells. Tell students that we do not know what triggers a cell to divide but the next activity will model some of the factors which affect this process.



INVESTIGATION #15: CELL DIVISION

Name ______________
Section ____ Date ____

EXPANSION OF THE IDEA

Large and Small Cells

1. Obtain three different-sized agar blocks.
2. Place each block into a separate, labelled beaker. Cover each block with a solution of sodium hydroxide (Caution—handle with care) for 15 seconds. Pour off the sodium hydroxide and rinse the agar blocks with water.
3. Dump the rinsed blocks onto paper toweling. Cut each block in half and measure the depth to which each block has been stained. Record your observations on Table 15-2.

Table 15-2

Stained Blocks

Size of Block	Depth of Stain	Unstained Area
small ___ cm^3		
medium ___ cm^3		
large ___ cm^3		

4. In which block did the stain penetrate the most?

   Most penetration occurred in the small block.

5. List several substances that cells need to live.

   Substances needed are oxygen, food, and water.

6. List the substances that a cell needs to pass out.

   Cells need to eliminate carbon dioxide, water, and other wastes.

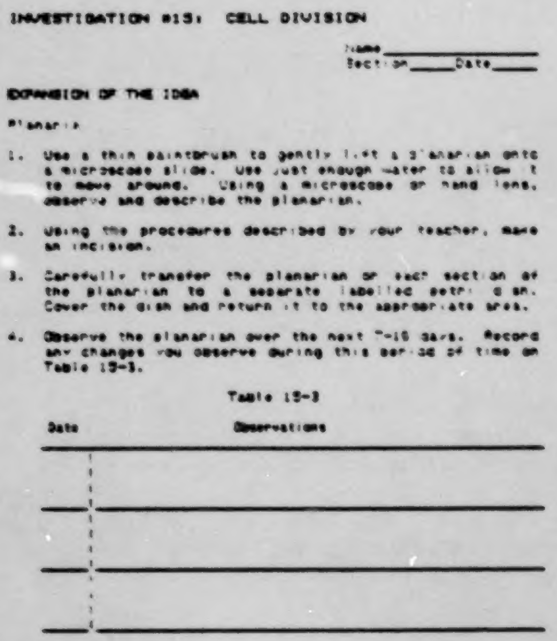
7. Why is the size of a cell important?

   Oxygen can diffuse more rapidly into smaller cells than into larger cells. Therefore, a small cell would be more efficient in getting oxygen to all of its parts.

Have the students set up the experiment as directed. Caution them to use the sodium hydroxide carefully. This solution is dangerous and can burn the skin. Remind the students to notify the teacher immediately if any spills occur.

Prepare agar blocks with phenolphtalein as follows: add 50 g. of agar to one liter of water, boil, add phenolphtalein, pour into pans to cool, slice into cubes of desired size. Prepare a 5% solution of phenolphtalein in alcohol, add one ml. per 100 ml. of agar. Using the sodium hydroxide concentrate, add 5 ml. per 100 ml. of water.

Concrete operational students will not understand the ratio of the area of the cell's outer surface to the volume of the cell. You could challenge your transitional or early formal operational students to find the surface and the volume of the three agar blocks. Early formal operational students can appreciate that the surface area does not expand at the same rate that the cell grows and increases in volume.



INVESTIGATION #15: CELL DIVISION

Name ____________
Section _____ Date _____

EXPANSION OF THE IDEA

Planaria

1. Use a thin paintbrush to gently lift a planarian onto a microscope slide. Use just enough water to allow it to move around. Using a microscope or hand lens, observe and describe the planarian.
2. Using the procedures described by your teacher, make an incision.
3. Carefully transfer the planarian or each section of the planarian to a separate labelled petri dish. Cover the dish and return it to the appropriate area.
4. Observe the planarian over the next 7-10 days. Record any changes you observe during this period of time on Table 15-3.

Table 15-3

Date	Observations

The flatworm planaria may be collected from slow-moving streams or ponds. If this source is used, the planaria should be cultured in the laboratory several weeks in advance. Direct students to look for these animals on the underside of rocks or sticks. In most cases, it is suggested to obtain planaria from a biological supply company. The brown or black varieties seem to be the hardiest. Follow their instructions for maintaining cultures. In caring for the planaria, transfer them in an eye dropper or use a small paintbrush. Food sources for the planaria include fresh liver and hard-boiled egg yolk. Be sure that planaria are transferred to a fresh water source after eating or microbial contamination will kill them. Planarians are large enough for the students to observe with a hand lens or a dissecting scope.

Tell the students how you want them to make incisions. Have the students place the planarian on a glass slide with just enough water to cover the worm. The greater the variety of incisions, the greater the possibilities for discussion. Possible incisions: split the head region, cut in half, either transverse or laterally, or split the tail region. Time required for completion of this activity will vary, allow 10-14 days. After the incision is made, have the students place the planaria or sections in marked petri dishes. Store the dishes in a cool, dark place. Observations can be brief and made at times that are convenient.

During the discussion, have the different groups describe the changes that occurred in their specimen. Place the petri dishes on the overhead projector to project the shadow of the planarian on the screen. From the students observations, focus on the following ideas: growth of new tails or heads; parts that decrease in size; and, sections that died. Ask students how the changes that occurred were possible. Lead them to the idea that the growth, repair, and regeneration (differentiation) were the result of mitotic cell division.

INVESTIGATION #15: CELL DIVISION

Name____________________
Section______Date______

EXPANSION OF THE IDEA

Reading Questions: Carrots, Cloning, and Cancer

1. Imagine you are raising money for the American Cancer Society. A person asked for a donation responds negatively. They do not want their money spent on studying carrots, flies, or worms. How would you respond.

   Basic research often uses simple organisms. Once the processes governing these organisms are understood, they can be applied to the more complex human systems.

2. In our modern society, it appears that everything causes cancer. Describe two factors implicated in causing cancer.

   Answers may vary. They may include factors such as radiation, chemical carcinogens, viruses, aging, and foods present or absent from our diet.

3. Discuss the pro's or con's of cloning experiments.

   Pro's: can grow spare parts; can replace diseased tissues with healthy tissues; can prolong life; and, can prevent aging.

   Con's: moral; ethical; legalistic considerations.

INVESTIGATION #16: REPRODUCTION

EXPLORATION

Eggs

CONCEPTUAL INVENTION (THE IDEA)

Some organisms develop from fertilized eggs.

EXPANSION OF THE IDEA

Reading: Common Birth Defects

INVESTIGATION #16: REPRODUCTION

INTRODUCTION

The concept for this investigation is: some organisms develop from fertilized eggs.

Many of the concepts about reproduction taught in traditional units are early or late formal.* Early formal concepts are: there are equal numbers of chromosomes in body cells after division, therefore, chromosomes must split; offspring must have the same number of chromosomes as each parent so gametes have half the chromosome number as body cells; and, every body cell has the same chromosome structure in the nucleus. Late formal concepts of reproduction are: the advantage of sexual reproduction as it relates to variation and change in the species; and, the function of mitosis and meiosis.

Early and late concrete students cannot assimilate many of those concepts. The concrete student can understand that reproduction leads to the continuous replacement of individuals, thus perpetuating the species, and that this is accomplished by two special cells combining to form an embryo. They also understand the mechanism of fertilization of plants and animals. The concrete learner can observe simple cause and effect actions of hormones such as puberty, but the study of hormones as a feedback system to maintain a dynamic equilibrium is a late formal concept.

Because of the level of concepts involved the Exploration phase of this investigation is limited to the examination of fertilized and unfertilized chicken or frog eggs. The development of a new individual should be the focus of attention. Technical descriptions of the developmental stages should be avoided.

The Expansion phase is left for the teacher to develop. The topic of reproduction is extremely important, yet most aspects are very formal; therefore, this learning cycle represents a suggested sequence of concrete experiences for the high school biology student. Additional aspects of human development most appropriate for individual communities are left to the discretion of the teacher.

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* Shayer M. and P. Adey, 1981. Towards A Science of Science Teaching, Heinemann Educational Books: London.

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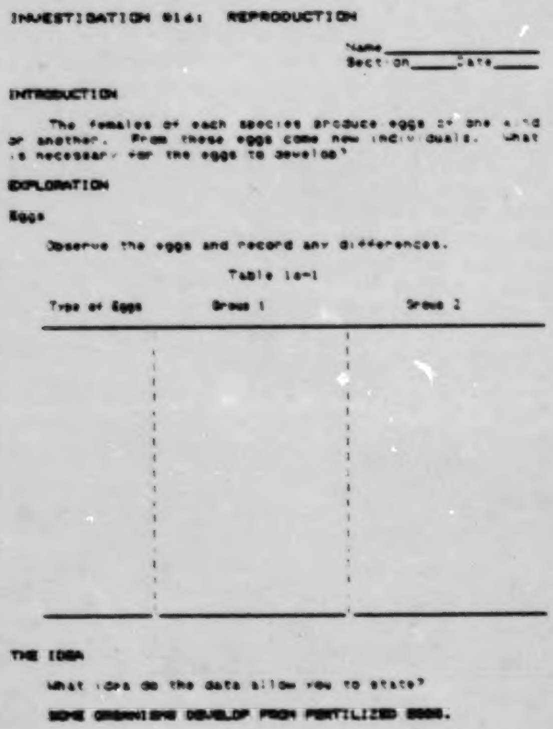
Conceptual invention may be achieved by using observations of organisms throughout the year. These could include discussion of gerbils, mealworms, flowering plants, or other organisms kept in the classroom. Illustrations or anatomical models may be used whenever possible. Videotapes such as "The Body Human: Miracle Months" or "Nova: The Miracle of Life" are excellent.

The concept of this investigation is expanded to include the following related content: reproduction is necessary for increasing the number of organisms and for perpetuating the species; two "special" cells combine to form an embryo; and, fertilization may occur externally or internally. The equipment needed for this investigation follows.

EXPLORATION

Eggs

- Eggs (chicken or frog, fertile and unfertile)
- petri dishes
- dissecting scopes
- incubator
- scissors
- forceps



INVESTIGATION #14: REPRODUCTION

Name______________

Section_____Date_____

INTRODUCTION

The females of each species produce eggs of one kind or another. From these eggs come new individuals. What is necessary for the eggs to develop?

EXPLORATION

Eggs

Observe the eggs and record any differences.

Table 14-1

Type of Eggs	Group 1	Group 2

THE IDEA

What idea do the data allow you to state?

SOME ORGANISMS DEVELOP FROM FERTILIZED EGGS.

Provide students with the necessary instructions regarding the care, handling, observation, and disposal or preservation of the eggs they are observing. If avian eggs are available, an incubator will be needed. Frog eggs may be purchased from most biological supply companies or collected locally depending upon the season. One group of eggs should be fertile and the other group should be unfertile. You may have students begin to incubate eggs at different time intervals up to three weeks. This way, they can make their observations of eggs in one day.

For the Conceptual Invention phase, have the students refer to their data sheet. Ask them to explain their data through questions such as the following: identify some organisms that produce their offspring by themselves--without a partner (Planaria, Bryophyllum bacteria or yeast); and, identify some organisms that require two parents to produce offspring (frogs, chickens, and mammals). Explain that in sexual reproduction, two "special" cells combine to form an embryo.

During the Expansion phase, additional experiments or discussions may precede the reading.

INVESTIGATION #16: REPRODUCTION

Name__________________
Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: Common Birth Defects

1. A young woman discovers that she is pregnant. She insists that she will not need a doctor until the baby is born. How would you respond to her?

   Yes, she may be fine; but, it is critical to the healthy development of her baby to have the best care possible. If problems are prevented or detected early enough, they may be eliminated.

2. Why are women encouraged not to smoke during a pregnancy?

   Smoking causes a lack of oxygen to the fetus. An oxygen deficiency may cause problems.

3. Why is the first trimester of pregnancy the most important?

   It is during the first trimester that the crucial process of differentiation is occurring. This leads to the development of the systems, including the nervous system.

TEACHER'S GUIDE

INVESTIGATION #17: INHERITANCE

EXPLORATION

Characteristics

CONCEPTUAL INVENTION (THE IDEA)

Observable characteristics are passed from parents to their offspring.

EXPANSION OF THE IDEA

Problem: Punnett Squares

Blood Typing

Reading: Genetic Chance

INVESTIGATION #17: INHERITANCE

INTRODUCTION

The concept for this investigation is: charcteristics are passed from parents to their offspring.

For a complete understanding of inheritance, students must understand that offspring have the same number of chromosomes as each of their parents. This requires an understanding of the functions of meiosis and mitosis. Even though formal reasoning is required for a complete understanding of inheritance, students can compare concretely their own characteristics to those of other family members.

During the Exploration phase, the students will compare a set of their own traits with those of the class. Then the students will compare their own traits with those of their family members.

In the Expansion phase, the students will be trained in the use of probabilities and the Punnett square. Concrete students can be trained to use the Punnett square in simple genetic problems and can use 1:1 and 1:2 correspondences. During the Expansion phase, the students will have the opportunity to test their own blood types. The chemical differences in the blood of different people will allow them to add another characteristic to the list of those that are inherited. The reading further applies the concept to human genetics.

The concept is expanded to include the following related content: certain characteristics are common in the human population; one characteristic may vary greatly from one person to the next; and, the blood of different people may vary chemically. The equipment needed for this investigation follows.

EXPLORATION

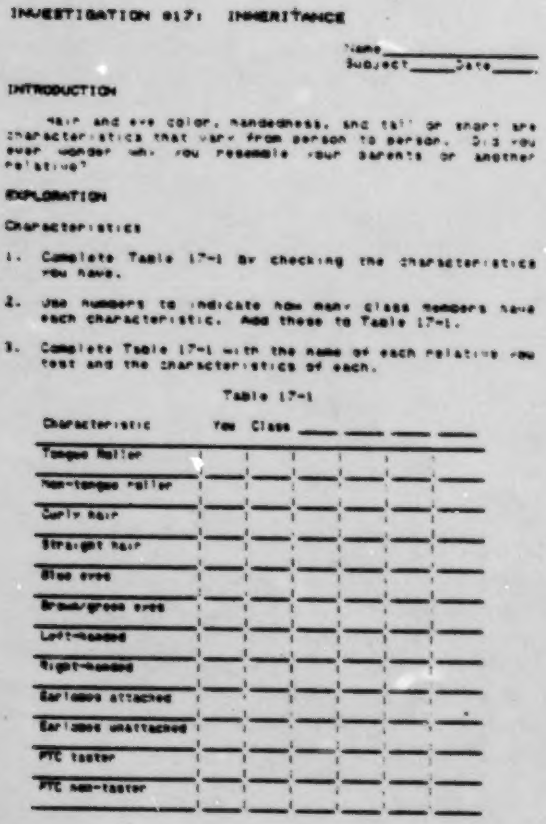
Characteristics

PTC paper

EXPANSION

Blood Typing

sterile blood lancet
Antigens A and B (Blood Typing Serum)
toothpicks
RH factor antigens
alcohol
cotton
slides
glass marking pencil



INVESTIGATION #17: INHERITANCE

Name__________________
Subject_____Date_____

INTRODUCTION

Hair and eye color, handedness, and tall or short are characteristics that vary from person to person. Did you ever wonder why you resemble your parents or another relative?

EXPLORATION

Characteristics

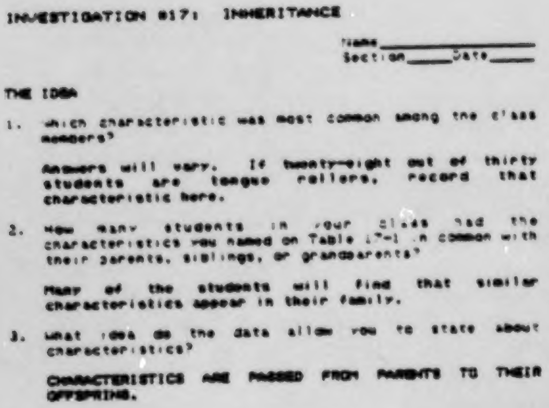
1. Complete Table 17-1 by checking the characteristics you have.
2. Use numbers to indicate how many class members have each characteristic. Add these to Table 17-1.
3. Complete Table 17-1 with the name of each relative you test and the characteristics of each.

Table 17-1

Characteristic	You	Class	____	____	____	____
Tongue Roller						
Non-tongue roller						
Curly hair						
Straight hair						
Blue eyes						
Brown/green eyes						
Left-handed						
Right-handed						
Earlobes attached						
Earlobes unattached						
PTC taster						
PTC non-taster						

Demonstrate the difference between attached and unattached earlobes and how to determine if they are tongue rollers. The PTC test should be the last trait examined. Most of the class will want to rinse their mouth. A great amount of interest and discussion will be generated if each characteristic is completed as a class. Tell the student to choose each of the characteristics they most nearly resemble.

Assign Question #3 as homework. The students should gather data from their parents as well as from other relatives. Suggest that students whose parents or other family member cannot participate, should ask a neighbor or school friend's family for their characteristics.



INVESTIGATION #17: INHERITANCE

Name______________
Section_____Date_____

THE IDEA

1. Which characteristic was most common among the class members?

   Answers will vary. If twenty-eight out of thirty students are tongue rollers, record that characteristic here.

2. How many students in your class had the characteristics you named on Table 17-1 in common with their parents, siblings, or grandparents?

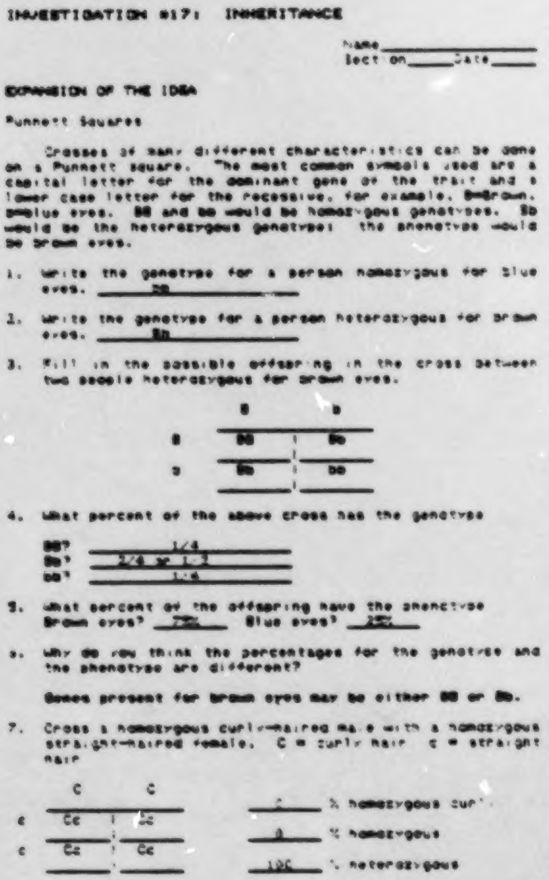
   Many of the students will find that similar characteristics appear in their family.

3. What idea do the data allow you to state about characteristics?

   CHARACTERISTICS ARE PASSED FROM PARENTS TO THEIR OFFSPRING.

Refer the students to Table 17-1 for the discussion. Hand out The Idea sheet. Have students suggest and record the most commonly occurring situation for each characteristic. Tell the students that those characteristics that appear most often in a population are called dominant, while the less often appearing characteristics are called recessive. These traits are carried on genes. These explanations of dominant and recessive traits are given with the concrete operational learner in mind. We recognize that they are incomplete and could lead to misconceptions. They will be clarified later. Ask the students to share their family data. You may want to complete several family trees with one of the traits.

Ask the students to compare their characteristics with their mothers and fathers. Through examples from student data, show the students that they have characteristics from both parents. Some of these characteristics are just like their mother or father, while some are a blend of the two or may be just like a grandparent's characteristics.



INVESTIGATION #17: INHERITANCE

Name________________

Section_____ Date_____

EXPANSION OF THE IDEA

Punnett Squares

Crosses of many different characteristics can be done on a Punnett square. The most common symbols used are a capital letter for the dominant gene of the trait and a lower case letter for the recessive, for example, B=brown, b=blue eyes. BB and bb would be homozygous genotypes. Bb would be the heterozygous genotype; the phenotype would be brown eyes.

1. Write the genotype for a person homozygous for blue eyes. __bb__

2. Write the genotype for a person heterozygous for brown eyes. __Bb__

3. Fill in the possible offspring in the cross between two people heterozygous for brown eyes.

	B	b
B	BB	Bb
b	Bb	bb

4. What percent of the above cross has the genotype

BB? __1/4__

Bb? __2/4 or 1/2__

bb? __1/4__

5. What percent of the offspring have the phenotype Brown eyes? __75%__ Blue eyes? __25%__

6. Why do you think the percentages for the genotype and the phenotype are different?

Genes present for brown eyes may be either BB or Bb.

7. Cross a homozygous curly-haired male with a homozygous straight-haired female. C = curly hair c = straight hair

	C	C
c	Cc	Cc
c	Cc	Cc

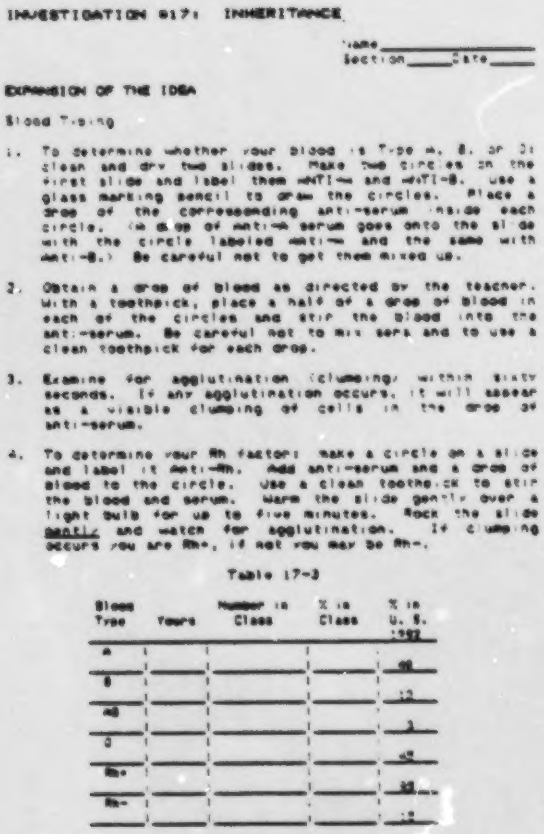
__0__ % homozygous curly

__0__ % homozygous

__100__ % heterozygous

At this point, review students on the models of mitosis, Investigation #15 and meiosis. Apply the chromosome models (using yarn, pop-beads or diagrams) to the concept. Add the language of genes, homozygous, heterozygous, genotype, and phenotype to the concept. This would be the appropriate time to return to the earlier explanations of dominant and recessive traits and discuss alleles. Lead to a more complete explanation for the formal students. A dominant gene is a gene that exerts its full effect no matter what its allelic partner may have. A recessive gene pertains to the gene that is not expressed if the allelic gene is dominant. Explain that the chromosomes that occur in each offspring are a result of chance, but that by using probabilities we can determine the possible combinations. Include activities in probability. Concrete students can manipulate 1:2 probabilities. Flipping coins works well for this. For the early formal students, the teacher may wish to include dice or other suitable materials to determine other probabilities.

When explaining to the students the use of the Punnett square, it is helpful to work with half of the box at a time. Begin with one characteristic. The dihybrid cross should be saved for early formal students. After working through several problems as a class, pass out the student sheet for the Problem: Punnett Squares.



INVESTIGATION #17: INHERITANCE

Name ____________
Section _____ Date _____

EXPANSION OF THE IDEA

Blood Typing

1. To determine whether your blood is Type A, B, or O: clean and dry two slides. Make two circles on the first slide and label them ANTI-A and ANTI-B. Use a glass marking pencil to draw the circles. Place a drop of the corresponding anti-serum inside each circle. (A drop of Anti-A serum goes onto the slide with the circle labeled Anti-A and the same with Anti-B.) Be careful not to get them mixed up.
2. Obtain a drop of blood as directed by the teacher. With a toothpick, place a half of a drop of blood in each of the circles and stir the blood into the anti-serum. Be careful not to mix sera and to use a clean toothpick for each drop.
3. Examine for agglutination (clumping) within sixty seconds. If any agglutination occurs, it will appear as a visible clumping of cells in the drop of anti-serum.
4. To determine your Rh factor: make a circle on a slide and label it Anti-Rh. Add anti-serum and a drop of blood to the circle. Use a clean toothpick to stir the blood and serum. Warm the slide gently over a light bulb for up to five minutes. Rock the slide gently and watch for agglutination. If clumping occurs you are Rh+, if not you may be Rh-.

Table 17-3

Blood Type	Yours	Number in Class	% in Class	% in U. S. 1982
A				40
B				12
AB				3
O				45
Rh+				85
Rh-				15

Provide blood-typing kits, slides, alcohol, cotton balls, and band-aids for each lab group. Students should be given the option as to whether or not they wish to determine their blood group. Make sure the students follow directions very closely with this experiment. Read over and demonstrate all procedures, especially how to use the lancet. Either prepare examples of the procedure and results or provide students with appropriate diagrams. Remind students to use only half a drop of blood in each of the Anti-sera.

During class discussion, place a chart similar to Table 17-3 on the board or on an acetate sheet for the overhead. Ask the students to share their data. Have students figure class averages. Discuss the distribution of blood groups in the class as compared to normal. Add to the concept: biochemical characteristics are passed from parents to their offspring.

INVESTIGATION #17: INHERITANCE

Name____________________
Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: The Genetic Chance

PKU (phenylketonuria) is an inherited condition of mental retardation. However, early diagnosis is essential since this disease is treatable. Homozygous recessive genes fail to make a necessary enzyme. Victims cannot digest proteins containing a certain amino acid. Therefore, victims are given a diet low in this amino acid. How the high levels of this amino acid bring about mental retardation is not yet known.

1. What are the chances of two carriers of PKU having a child who has the deficiency? The key for Table 17-6 is P = normal gene, p = defective gene.

Table 17-6

	Carrier	Carrier
parents	Pp	Pp
possible gametes	P p	P p

possible offspring (F1 generation)	P	p
P	PP	Pp
p	Pp	pp

Genotypic ratio:
25 % normal
50 % carriers
25 % having defect

2. Infants are now screened at birth for PKU because of laws in forty-eight states. Is this screening an invasion of privacy? State your reasons.

Answers may vary, but should consider the cost of raising a PKU child versus the cost of screening. Also early treatment makes the disease preventable, if the special diet is maintained.

While at play, a young black child tires easily, becomes pale, and complains of pains in the arms, legs, back, and abdomen. His appetite is poor. A chest cold brings on a crisis, a period when pain and other symptoms are severe. A doctor examines a blood sample which reveals abnormally-shaped red blood cells. Instead of being disc-shaped, they are shaped like a crescent or sickle. Sickle-cell anemia is another example of a recessively inherited disorder.

3. If a man with sickle-cell anemia marries a woman who is a carrier, what are the chances that a child will inherit the disease? Key for Table 17-7 is S = normal gene, s = defective gene.

	Carrier	Carrier
parents	ss	Ss
possible gametes	s s	S s

possible offspring (F1 generation)

	s	s
S	Ss	Ss
s	ss	ss

Genotype Ratio

0 % normal
50 % carriers
50 % disease

TEACHER'S GUIDE

INVESTIGATION #18: HOMEOSTASIS

EXPLORATION

Body Thermostats

Changing Conditions

CONCEPTUAL INVENTION (THE IDEA)

Organisms are capable of adjusting to changes in the environment.

EXPANSION OF THE IDEA

Reading: The Heat is On

INVESTIGATION #18: HOMEOSTASIS

INTRODUCTION

The concept for this investigation is: organisms are capable of adjusting to changes in the environment.

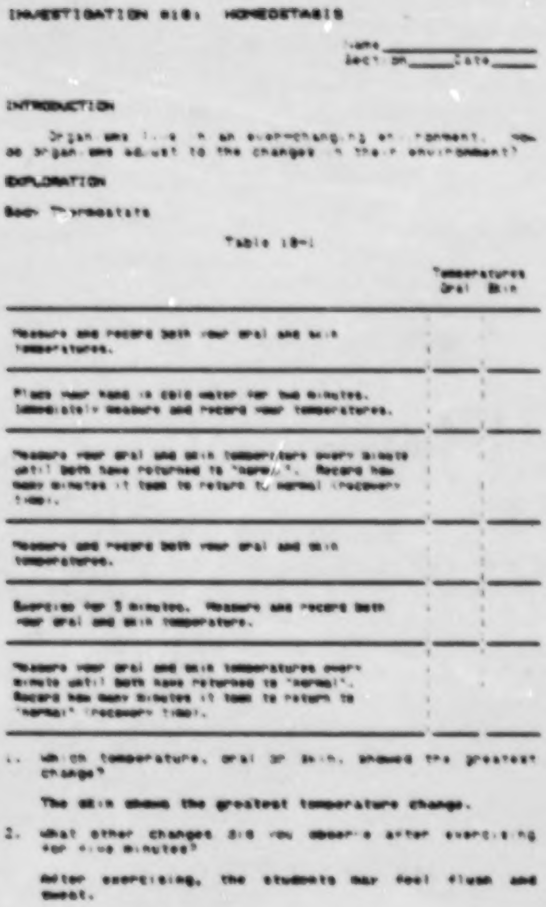
During the Exploration phase the students test the reactions of their own body temperatures to hot and cold water. The students will be asked to recall things that have happened in previous investigations throughout the year. From those experiences, the students will be asked to draw inferences to invent the concept. The concept of homeostasis is discussed using simple action-reaction systems, not the complex feedback systems that actually occur within organisms in the maintenance of a dynamic equilibrium. The Conceptual Invention discussion serves as an organizer for the completion of the course. The Expansion phase includes one reading that describes how different animals regulate their internal environment.

The concept is expanded to include the following related content: body systems may change to adjust to changes in the environment; some organisms keep a steady state inside their bodies; and, organisms have many mechanisms for maintaining a steady internal environment. The equipment needed for this investigation follows.

EXPLORATION

Body Thermostats

oral thermometers
strip thermometers
ice and water
laboratory thermometers
totetrays or buckets



INVESTIGATION #18: HOMEOSTASIS

Name ______________
Section _____ Date _____

INTRODUCTION

Organisms live in an everchanging environment. How do organisms adjust to the changes in their environment?

EXPLORATION

Body Thermostats

Table 18-1

	Temperatures Oral	 Skin
Measure and record both your oral and skin temperatures.		
Place your hand in cold water for two minutes. Immediately measure and record your temperatures.		
Measure your oral and skin temperature every minute until both have returned to "normal". Record how many minutes it took to return to normal (recovery time).		
Measure and record both your oral and skin temperatures.		
Exercise for 5 minutes. Measure and record both your oral and skin temperature.		
Measure your oral and skin temperatures every minute until both have returned to "normal". Record how many minutes it took to return to "normal" (recovery time).		

1. Which temperature, oral or skin, showed the greatest change?

   The skin shows the greatest temperature change.

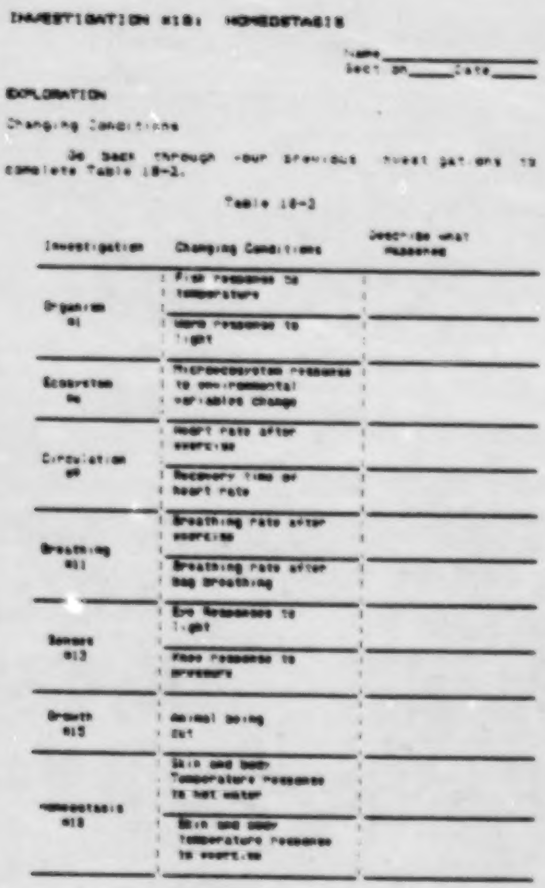
2. What other changes did you observe after exercising for five minutes?

   After exercising, the students may feel flush and sweat.

Three types of thermometers will be needed for this activity. A clinical oral (not rectal) thermometer should be used to take oral temperatures; a laboratory thermometer should be used for measuring the temperature of the water in the pan or totetray; a strip or thermistorized thermometer should be used for taking skin temperature. The strip thermometer is quite sensitive. Instruct students on the proper use and care of each type of thermometer. To disinfect thermometers, provide a dilute solution of chlorine bleach and water. Dip the clinical and laboratory thermometers and wipe the strip thermometer with a cottonball. Carefully rinse each. Do not use alcohol or acetone on a strip thermometer.

The water bath must be maintained at a constant temperature of 10° C. Several water baths may be used or only one central large container will suffice. Ample icecubes should be readily available.

As students are performing this activity, circulate around the room. Students with their forearms immersed in ice cold water may need encourgement, while those who are exercising may need supervision. Choose one form of exercise, jogging in place or in a specified area for all participants. Assign each student to a specific role to perform during this activity.



INVESTIGATION #18: HOMEOSTASIS

Name________________
Section_____Date_____

EXPLORATION

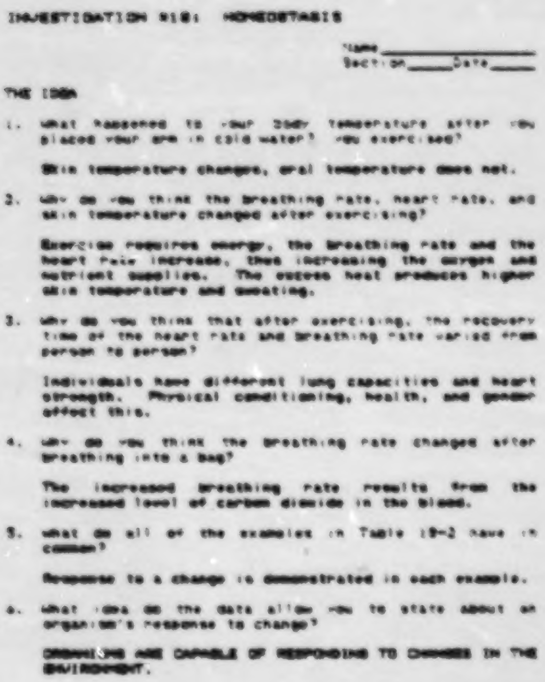
Changing Conditions

Go back through your previous investigations to complete Table 18-2.

Table 18-2

Investigation	Changing Conditions	Describe what happened
Organism #1	Fish response to temperature	
	Worm response to light	
Ecosystem #4	Microecosystem response to environmental variables change	
Circulation #9	Heart rate after exercise	
	Recovery time of heart rate	
Breathing #11	Breathing rate after exercise	
	Breathing rate after bag breathing	
Senses #13	Eye Responses to light	
	Knee response to pressure	
Growth #15	Animal being cut	
Homeostasis #18	Skin and body Temperature response to hot water	
	Skin and body temperature response to exercise	

To complete Table 18-2, the students will need a well-organized notebook. They may work individually first, then as a group or as the teacher chooses. They are asked for previous observations from which they can infer a similarity. You may wish to delete any acivities that your students did not perform from the list in Table 18-2. Begin the activity by discussing the first one or two examples.



INVESTIGATION #18: HOMEOSTASIS

Name ____________
Section _____ Date _____

THE IDEA

1. What happened to your body temperature after you placed your arm in cold water? You exercised?

   Skin temperature changes, oral temperature does not.

2. Why do you think the breathing rate, heart rate, and skin temperature changed after exercising?

   Exercise requires energy, the breathing rate and the heart rate increase, thus increasing the oxygen and nutrient supplies. The excess heat produces higher skin temperature and sweating.

3. Why do you think that after exercising, the recovery time of the heart rate and breathing rate varied from person to person?

   Individuals have different lung capacities and heart strength. Physical conditioning, health, and gender affect this.

4. Why do you think the breathing rate changes after breathing into a bag?

   The increased breathing rate results from the increased level of carbon dioxide in the blood.

5. What do all of the examples in Table 18-2 have in common?

   Response to a change is demonstrated in each example.

6. What idea do the data allow you to state about an organism's response to change?

   ORGANISMS ARE CAPABLE OF RESPONDING TO CHANGES IN THE ENVIRONMENT.

Refer students to Table 18-1. Ask them to share their data as you display it on a similar chart. During discussion of the data from "Body Thermostats", ask: how did your hand feel when it was in the cold water? (cold, numb, uncomfortable); what did the cold water do to your skin temperature? (lowered it); what happened to your skin temperature after you removed your hand from the icewater? (it increased or warmed); what do you think might happen if your internal body temperature increased greatly, for example, if they have a high fever? (overheat and become ill or die). Name other situations in which your hands have been cold (skiing, snowstorm, football games); name several ways by which you could have increased your recovery time or warmed up quickly (exercising rubbing the exposed area, covering up); and, what are some ways in which your body reacts to being cold? (shivering) Our bodies also may process food or metabolize faster.

This is not observable so concrete students may be told this. Tell the student that our body also reacts to this heat loss with a decrease in blood flow to our hands and other extremities.

Next, refer the students to their data on Table 18-2. Ask them to share their descriptions of what happened in each instance so that representative descriptions can be developed. Using a chart similar to Table 18-2, record these on the board or on an acetate sheet on the overhead. Ask for simple cause-and-effect reasons behind some of the mechanisms they have observed.

The name of the process by which organisms adjust: HOMEOSTASIS. For example, the changing of the breathing rate is a homeostatic mechanism. Organisms keep a steady inside environment (i.e., temperature) when the outside environment changes. The idea involves complex mechanisms which will not be discussed because of their abstract nature. Organisms which are able to regulate their own body temperature are called homeotherms. The teacher may wish to compare warm-blooded animals and cold-blooded animals at this point.

INVESTIGATION #18: HOMEOSTASIS

Name________________
Section_____Date_____

EXPANSION OF THE IDEA

Reading Questions: The Heat is On

1. In what two ways to animals regulate the internal temperature of their body?

   People sweat; turtle froth at the mouth; alligators open their mouth or swim to the bottom of a pond; prairie dogs stay inside.

2. Describe one example of temperature regulation that involves a physiological change.

   Jackrabbit's large ears have lots of blood vessels.

3. Describe one example of another way (besides using physiological changes) animals regulate their internal conditions.

   Collared lizards sun themselves; birds migrate.

4. List three internal factors which must be constantly kept stable.

   water, salt, glucose

APPENDIX A

MICROSCOPE SKILL BUILDER

STUDENT MATERIALS

AND

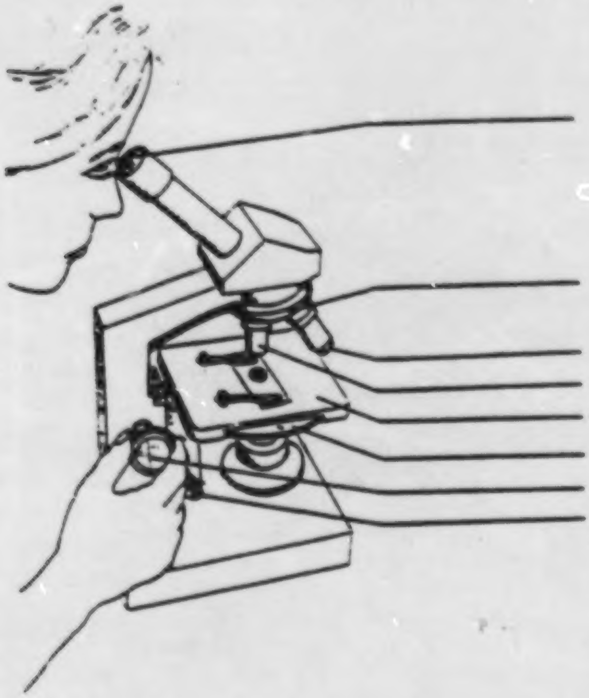
TEACHER'S GUIDE

THE MICROSCOPE SKILL BUILDER

Name__________________
Section_____Date_____

The microscope is a very sensitive instrument. Careful handling will improve your skill in observing microscopic specimens.

1. Identify those parts that are numbered on the diagram.



2. What happens when:

   the coarse adjustment knob is turned one full turn?

   the fine adjustment knob is turned one full turn?

3. How does the distance between the scanner lens and stage compare to the distance between the low power lens and stage?

RULE #1: Before placing or removing the slide, always place the scanner lens in viewing position.

4. Focusing on Scanner

Lower the stage and place slide 'F' in viewing position (cover slip 'up') so that the specimen is 'centered' above the stage lens. Raise the stage to its highest position (DO NOT allow slide to touch the lens). While looking through the ocular, slowly lower the stage using the coarse adjustment until focused.

5. Practice focusing

Focus the slide on the letter "F" using scanner. Observe the slide directly (not through the microscope).

F

What is different about the appearance of the letter "F" when observed directly compared to its appearance as seen through the microscope?

Without moving the slide, place the Low Power lens into viewing position. Adjust the focus by slowly turning the fine adjustment knob. Can the letter "F" still be seen without moving the slide? ________

While viewing, slowly move the slide until the capital letter "F" is upside down. Return the scanner to viewing position. Is the letter "F" still centered?

____

RULE #2: After locating the area to be examined, it must be centered before using a higher power lens.

6. Practice using the high power lens

Using correct procedures, focus a printed period located in slide "B" on low power. In the circle labeled "Scanner", draw the period as it appears in the microscope. Focus and draw the period using low power. Was the period seen in the center of the field? ________ (If not, review Rule #2.) NOTE: Have the two drawings approved by the teacher BEFORE you continue. Place the high power lens into viewing position. While viewing, slowly turn the Fine Adjustment until a sharp focus is achieved. Draw the period exactly as it appears.

Scanner　　Low Power　　High Power

RULE #3: **Before focusing on High Power, focus the slide on Low Power.**

RULE #4: **NEVER turn the COARSE ADJUSTMENT when using High Power.**

TEACHER'S GUIDE

THE MICROSCOPE SKILL BUILDER

INTRODUCTION

The purpose of this activity is to enable students to use the microscope safely and proficiently. Materials and equipment for each student group are as follows.

- microscopes with light source
- transparent copy of microscope diagram
- newspaper print
- slides
- lens paper

TEACHER PREPARATION

A microscope maintainence check prevents student frustration. Prepare a slide for each microscope which contains at least one capital letter "F" and one "period".

To begin the activity, caution the students to follow the steps in the order given. Tell the students to remove the microscope cover. As you identify each part listed on the student sheet, have the students locate it on their microscope. After the parts have been located and named, tell the students to turn the coarse adjustment knob forward and backward one full turn. NOTE: Be sure the high power lens is not in viewing position. Next, tell the students to turn the fine adjustment knob one full turn forward then backward. NOTE: If your microscopes have only low and high power lenses, simply omit those parts of the training that include the scanner (4X lens).

Tell the students to place the scanner lens in viewing position as you demonstrate. Have them raise the stage to its highest position (the safety stop should be engaged). As you demonstrate, have the students place the low power lens into viewing position. Have the students read Rule #1. Direct the students to complete the exercise, Focusing on Scanner, then have the students repeat the procedures using low power.

The Practice is designed to show students that the image of a specimen is inverted when viewed through the microscope. The students are shown the advantage of 'centering' the area to be observed before using a higher power lens. As students perform the Practice, each group should be monitored. When all groups have finished, a brief discussion of the questions and rules should follow. Instructions for proper storage of the slides and the microscope should be given.

If time permits, further practice on focusing other slides (on low power) may be done. Avoid having students practice on complex slides such as muscle or leaf cross sections. Several interesting slides which provide the opportunity to improve focusing and observation skills are easily prepared. Specimens easily obtained are feathers, small ants, mosquitoes, algae, hair, or eyelashes (you may want to show students how to make their own slides using these types of specimens).

APPENDIX B

SAMPLE ESSAY EVALUATION QUESTIONS

SAMPLE ESSAY EVALUATION QUESTIONS

INTRODUCTION

Throughout each investigation, students are asked to use their rational powers to intepret observations and data. Since this methodology is employed throughout each learning cycle, the evaluation materials reflect similar processes. These essay questions are the types of questions that should follow each investigation.

. The students are asked to use their rational powers on the content from each investigation. The sample test questions are presented as a guide to the teacher in preparation of evaluation questions.

Student evaluation should not be limited to these essay test questions or test questions only. Student evaluation should occur throughout each investigation and it is recommended that data sheets, charts, graphs, and investigation questions be used to evaluate student performance.

INVESTIGATION #1: ORGANISM

1. Describe five life processes that make a rabbit an organism.

2. A newt, a type of salamander, was found under a dead log. This log was located beneath a large shade tree on the bank of a stream. Explain how this habitat provides the needs of a newt.

3. The ability to move is a definition often used to describe an animal. Is a tape recorder an animal because it has movable parts? Explain.

4. When dandelions go to seed, they form light structures. A puff of breath or wind will dislodge the seed and it will float through the air. Since this portion of the dandelion can move from place to place, explain why it isn't an animal.

5. How would you set up an experiment to find out if seeds can sprout without water?

6. When biologists discovered organisms called viruses, the scientists could not decide if the viruses were living or non-living. How would you decide if the viruses were living or non-living?

7. Throughout this investigation, you have been working to build your powers of observation. Your teacher has provided an object. Give a detailed description of this object.

INVESTIGATION #2: CLASSIFICATION

1. While on a field trip with your class, you observe a new, unidentified organism. You observe that it eats grass, has two legs, and hops. Which characteristics would you use to classify it?

2. What problems might arise if an organism were classified according to its habitat?

3. Euglena is a microscopic organism that is green like a plant. However, it can swim and has mouthlike parts like an animal. Why did scientists argue about whether Euglena is a plant or an animal, before classifying it in the Kingdom Protista?

4. Classification systems are manmade and subject to change as more information becomes available to us. In the past, scientists used a classification system that had only two kingdoms--Plantae and Animatia. Recently, a five kingdom classification system has been proposed. What may be the basis for separating into a three, four, or a five kingdom system?

5. Make an identification key that can be used to identify the following fifteen common animals. Develop a key based on their observable characteristics (for example, structures, behaviors, food needs). Develop your own key.

earthworm
goldfish
man
frog
salamander
grasshopper
kangaroo
rabbit
minnow
lizard
spider
robin
rattlesnake
bluejay
turtle

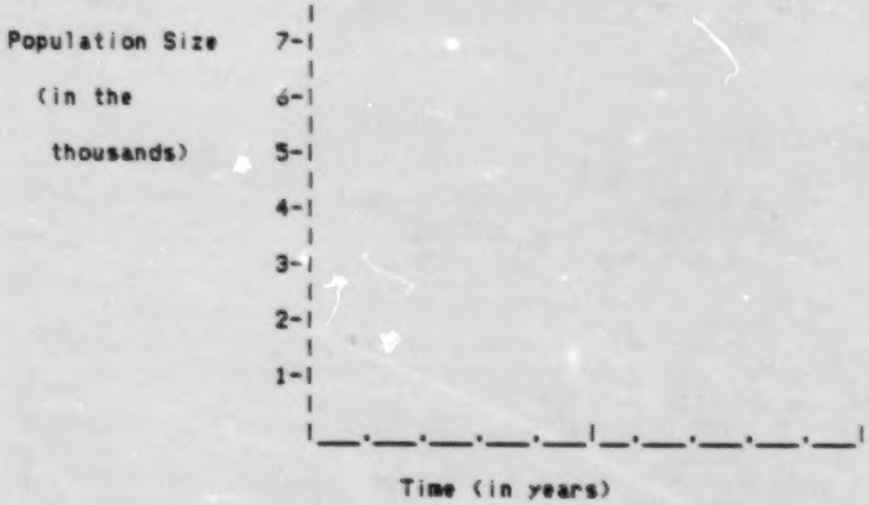
INVESTIGATION #3: POPULATIONS

1. If a species is endangered, is its birth rate greater than its death rate? Explain.

2. "Zero Population Growth" means that the birthrate of a population equals the populations's death rate. Some people feel that the human population should have zero population growth. Why might these people feel this way?

3. Sample population problem.

   A population exhibited the following changes over a ten (10) year period of time. A drought hit in the seventh summer. This resulted in the development of a poor mast crop (acorns, nuts) in the fall of that year. This is the normal winter food for the turkeys.

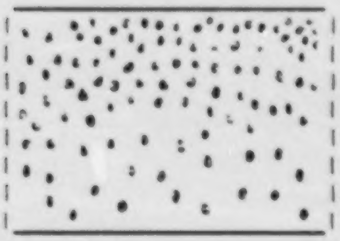


   a. Predict what will happen to the carrying capacity of the habitat after year seven.

   b. List two factors (other than a good food supply) which can increase the carrying capacity of a habitat.

   c. List two factors (other than a poor food supply) which can decrease the carrying capacity of a habitat.

4. How would you estimate the total population of "dot bugs" in the quadrat below? Describe and show all work. Label the parts of the problem clearly so that anyone can follow what you do.



Describe methods to use for the same quadrat in Question 4 above if the population were moving.

5. Why do you think it is important for rangers to sample deer population before setting the length of the hunting season?

INVESTIGATION #4: PRODUCERS

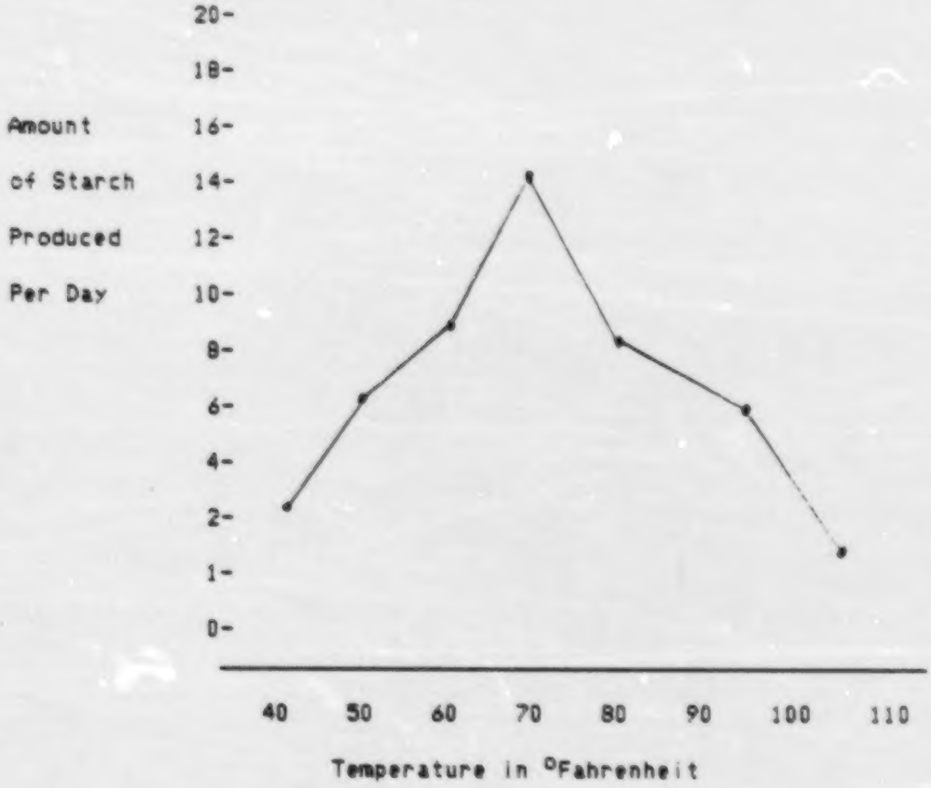
1. Biologists who help plan future cities in space, include many green plants in these cities. Why would green plants be necessary in future cities in space?

2. Why is a variegated-leafed plant useful for demonstrating that chlorophyll is necessary for photosynthesis? (Use control and single variable in your answer.)

3. A student pinned disks of cork on opposite sides of a geranium leaf. The plant was kept in sunlight for several hours. The leaf was removed from the plant and the corks removed. Then, to remove the chlorophyll, the leaf was boiled in alcohol. The white leaf was covered with Lugol's iodine solution. The uncovered part of the leaf turned blue-black, the covered part remained the color of iodine. What conclusion can be made from this experiment? What is the variable in this experiment? ____________________ What is the control in this experiment? ____________________

4. Set up an aquarium containing only sand, pond water, and fish. The next day, the fish were found to be floating dead at the top. Explain why the fish died. Suggest one way to solve the student's problem.

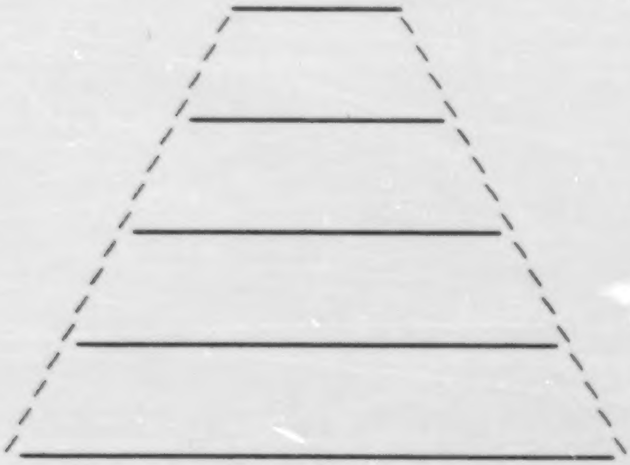
5. A gardener in the southern U. S. began to grow Irish potatoes on June first. When they harvested them later in the year, they obtained very few potatoes, and the potatoes were very small. What went wrong? Examine the graph below which illustrates the optimum temperature for the growth of Irish potatoes. Record your ideas as to what went wrong.



INVESTIGATIONS #5: FOOD CHAINS

1. Explain why scientists represent food chains as pyramids that are smaller at the top than at the bottom.

2. Make a diagram of a food web that exists in your local area. Organize the answers in the food pyramid below.



3. How would a food web be affected if there were no decomposers?

4. List two reasons why the number of predators is always lower than the number of prey.

5. Give an example of how the death of one animal provides food for another animal.

6. What effect would the extermination of all the decomposers in an area have upon the consumer and producer populations in that area?

7. The Kaibib Plateau community of Arizona had thriving populations of deer, wolves, coyotes, and mountain lions. The producers of the community provided plentiful cover and food. In order to protect the deer of the community, man systematically reduced the predator populations. As a result, the deer population increased from about 4,000 to 100,000 in less than twenty years.

INVESTIGATION #6: ECOSYSTEM

1. List four biomes below. Describe an important environmental variable for each biome and list at least two important plant and animal populations.

Biome	Describe One Important Environmental Variable	Plant Populations	Animal Populations
A		1 2	1 2
B		1 2	1 2
C		1 2	1 2
D		1 2	1 2

2. Give an example of how one animal and one plant deal with extreme heat in hot deserts?

3. Explain how the climate determines the biome of a certain area.

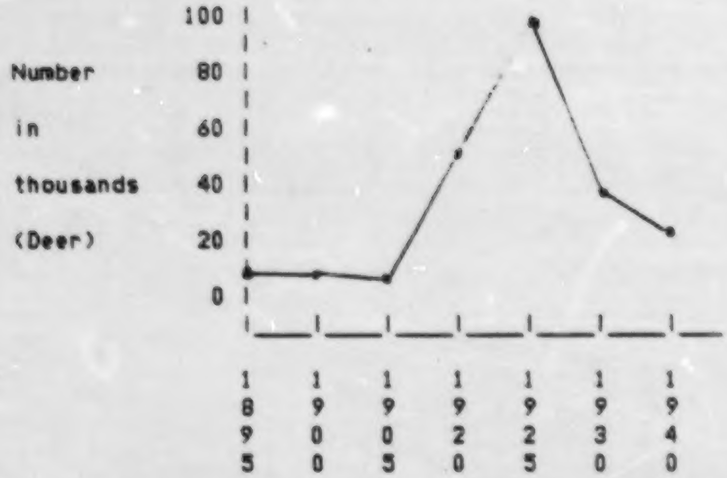
4. What adaptations to desert climates are found in mammals? in birds? in reptiles?

5. How would an ecosystem be affected if there were no producers?

6. Imagine an aquatic ecosystem. If harmful chemicals are dumped into a lake, they often settle to the bottom and on plants. Catfish are bottom feeders and may eat these fish. Why are people warned not to eat too many of these fish?

7. If the earth were covered by snow and ice, what adaptations would allow an organism to survive?

8. Criticize the following statement: Insecticides such as DDT kill insects and are not harmful to humans.



a. What do you think caused the deer population to change between 1905 and 1920?

b. Describe what might have caused the change between 1925 and 1927?

c. What might cause the changes that occurred between 1927 and 1935?

INVESTIGATION #7: CELLS

1. If all cells were alike, that is, they did not differentiate, would humans exist? Explain.

2. Why do some biologists say that the cell is the basic unit of life?

3. Draw and label the parts of a green plant cell that you observed under the light microscope.

4. Compare the similarities between a typical plant and animal cell.

5. Working in a police laboratory, you are given a tiny sample of material and asked to identify it as either plant or animal matter. How could you decide what it is?

INVESTIGATION #8: CELL TRANSPORT

1. Imagine that a fish that normally lives in fresh, unsalted water is put into a tank of saltwater. What probably will happen to the cells in the fish? Why?

2. Analyze the following situation, then answer the questions.

   A glucose solution is placed into dialysis tubing along with a starch solution. The tubing is placed into a beaker containing distilled water. After twenty minutes, the solution in the beaker and the solution in the dialysis tubing were tested with two separate indicator solutions, Benedict's Reagent and Lugol's Iodine Solution. The dialysis tubing was rinsed thoroughly to prevent any contamination between the solutions. (Benedit's Reagent turns from blue to red in the presence of glucose. Iodine turns blue-black in the presence of starch.) The following results were obtained.

	Solution Inside The Dialysis Tubing		Solution Outside The Dialysis Tubing	
	At Start	At Finish	At Start	After 20 Minutes
Glucose	+	+	-	+
Starch	+	+	-	-

   a. What part of the cell does the dialysis tubing represent?

   b. What substance, if any, diffused into the dialysis tubing?

   c. What substance, if any, diffused out of the dialysis tubing?

   d. Offer one logical explanation for the results of this experiment.

3. Bacteria, a single-celled organism, can cause a sore throat. A home remedy for treating sore throats is to gargle with salt water. Why is this treatment useful in destroying bacteria?

4. Cucumber sices that are approximately 90% water are placed in the following solutions. Explain what would happen in each solution. distilled water (100%)? a strong salt solution?

INVESTIGATION #9: CIRCULATION

1. Explain why your heart has a series of one-way valves.

2. What is the reason for saying, "We are as young as our arteries"?

3. Why can you feel a pulse in arteries and not veins?

4. How does exercise affect your circulatory system on a short-term and a long-term basis?

5. What is the most complete advise you can give someone to avoid cardiovascular disease?

6. I am a red blood cell. Trace my pathway through the heart from the vena cavas to the aorta. Describe the chambers, vessels, valves, and other organs through which I travel.

7. What happens to a red blood cell as it passes through:

   a. the right side of the heart

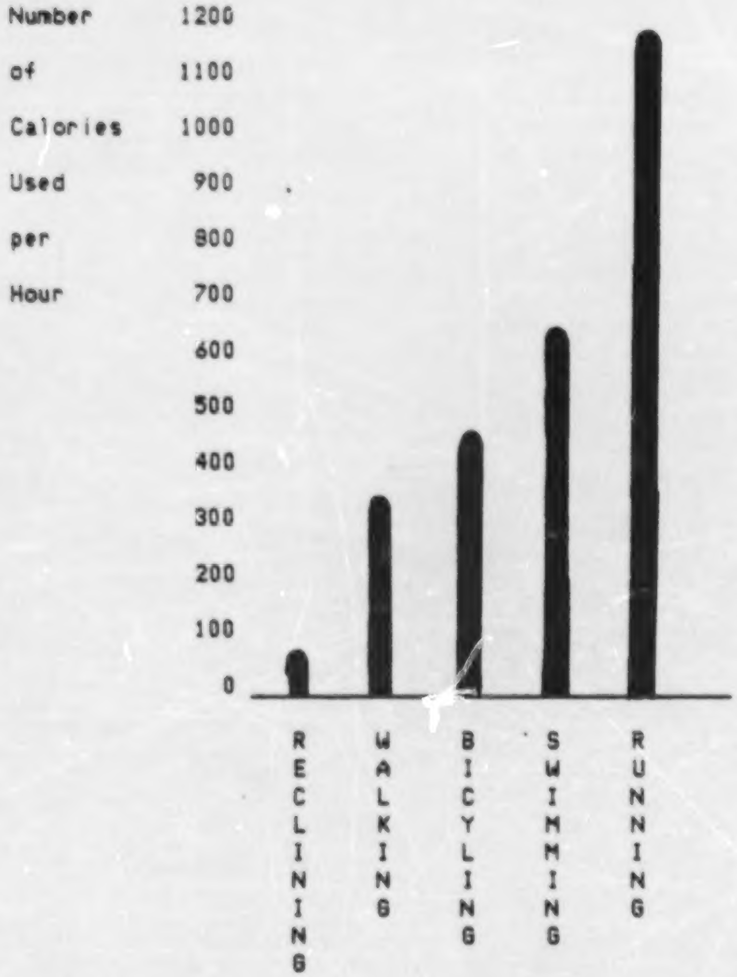
   b. the left side of the heart

   c. the lungs

   d. a capillary?

INVESTIGATION #10: CALORIES

1. The graph below provides you with the approximate number of calories used up for certain activities.



Activity: Use the above graph to solve the following questions. Show your work.

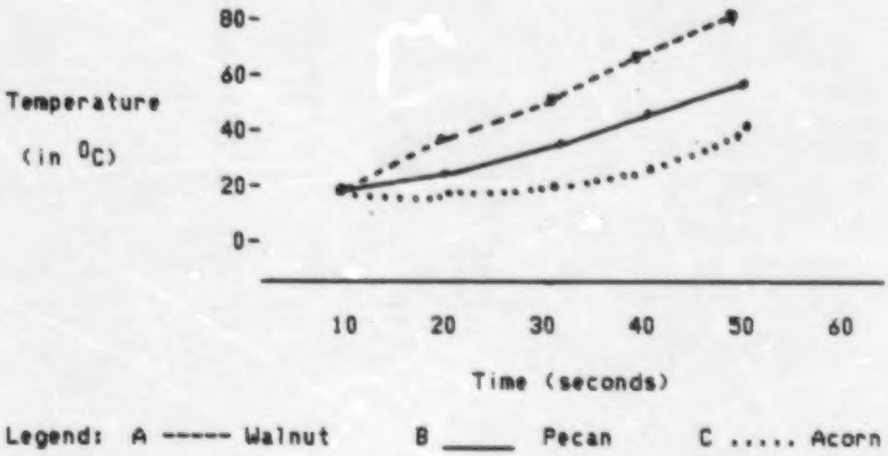
a. The average adult calorie intake is about 2,500 calories. Would this be enough for someone who runs for thirty minutes per day? Explain your answer.

b. An olympic class swimmer trains for about eight hours per day by swimming. How many calories would the swimmer require per day?

2. Give some logical suggestions as to the best ways to go on a heathy diet.

3. Defend or refute the following statement: dieting may be hazardous to your health.

4. Interpret the graph below to answer the following questions. A student was asked to see how much energy three varieties of nuts contained. One gram was burned for each type of nut. Once the sample was ignited, the heat produced was used to raise the temperature of 100 ml. of water in a beaker.



a. Which type of nut contained the most energy?

b. Calorie is the amount of heat required to raise the temperature of 1 g. of water 1 °C. How many calories were produced by the burning of the pecan?

5. Many animal populations rely upon nut crops as their food source throughout the winter. Design a controlled experiment to test the following problem: which type of nut contains the most stored energy--walnuts, pecans, acorns, peanuts, or almonds?

INVESTIGATION #11: DIGESTION

1. Vomiting empties the stomach. Why is it dangerous to lose weight by vomiting after you eat?

2. People who are strict vegetarians do not eat any meat or fish products. Why are most vegetarians extra careful about what they eat?

3. If you stood on your head while swallowing food, would the food still travel to your stomach? Explain. (Caution: do not try this!)

4. Some popular diets require that a person eat only foods that contain protein, such as fish, soybeans, milk, and eggs. Why might this diet be unhealthy?

5. Consider your laboratory activities for this investigation. Why is it necessary that you chew bread and potatoes thoroughly?

6. Why doesn't the digestive system digest itself?

7. Trace a Big Mac from the mouth to the anus. What type of food is digested and/or absorbed in each organ.

INVESTIGATION #12: BREATHING

1. Hiccups are caused by quick movements of the diaphragm. Why do these quick movements cause the sudden breathing that accompanies hiccups?

2. Emphysema, a disease which destroys the alveoli, can be caused by cigarette smoking. Why is emphysema a dangerous disease?

3. What changes would occur in your blood if you were to hold your breath for a few minutes?

4. Describe the actions of your respiratory system as you climb a flight of stairs. Be sure to include the reasons for each action.

5. Trace the pathway of air from the nose to a red blood cell in a lung capillary.

6. What happens to a red blood cell in the capillaries of the lungs?

7. Describe three changes that occur in your body from a long term program of aerobic exercising.

8. Why do you breathe rapidly after running?

9. Why do you feel so tired when you have an upper respiratory infection, that is, the common cold?

10. Why, after the finish of a 1,000 mile race, do runners pant very hard for several minutes?

INVESTIGATION #13: RESPONSES

1. A catarat is an eye problem in which the lens becomes foggy. How do cataracts affect vision?

2. Defend or refute the follwing statement: reflexes do not have to be learned.

3. After a chicken's head is cut off, it will continue to run around the yard for approximately five minutes. Why?

4. Suppose that a disease destroys your ability to feel painful stimuli. How would this be dangerous or helpful?

5. How might predators and prey rely on their senses?

6. Watch a robin catch worms. Hypothesize which sense(s) the robin is using to capture the worm. (The answer to this question is actually unknown at the present time.)

INVESTIGATION #14: LOCOMOTION

1. Why do muscles work in opposing pairs?

2. Explain why the skeleton has several kinds of joints.

3. Your hand and wrist have many joints in it. Why are there so many joints in a relatively small part of your body?

4. Predict what might happen if the cartilage between bones wore down.

5. If the chicken were to raise its wing in flight, how would each part listed below do its job?

   muscle
   nerve
   blood vessels and blood
   bone
   cartilage
   skin
   tendon
   ligament
   fat (adipose) tissue

INVESTIGATION #15: CELL DIVISION

1. A good diet is always important, but it is especially important to children and young adults. Why?

2. What is the advantage of having two small cells rather than one large one?

3. How is the study of mitosis important to cancer researchers?

4. In mitosis the two new "daughter" cells receive the same number of chromosomes as the parent cell. Why is this important?

5. Discuss two examples of when mitosis occurs in our bodies.

INVESTIGATION #16: REPRODUCTION

1. Why do many organisms produce more offspring than can possibly survive?

2. Organisms that undergo internal development usually produce and fertilize fewer eggs than do organisms that undergo external fertilization. Explain.

3. How does the number of sperms in the human compare to the number of eggs? Why is this important?

4. What benefit does the internal fertilization of reptile eggs have over the external fertilization of fish and amphibian eggs?

INVESTIGATION #17: INHERITANCE

1. Discuss how a cell in your body is related to the cells of your parents and your grandparents.

2. Explain how two organisms can have the same phenotype but different genotypes.

3. The phenotypic ratio of a certain cross is 3 red to 1 white. What are the possible genotypes of the parents? Show all work or use the Punnett squares to support your answer.

4. Why would a dog breeder pay a large sum of money to cross a female dog with a prize winning male dog?

5. How might a population study for a certain inherited disease reveal how that disease is inherited?

INVESTIGATION #18: HOMEOSTASIS TEST

1. When you blush, your face may become red, it may get warmer, and your heart may beat faster. How are the redness, warmness, and increased heart rate related?

2. How can the following be examples of homeostatic mechanisms? Choose one and explain.

   a food web
   diffusion
   mitosis
   an ecosystem
   the kidney
   photosynthesis and respiration
   shivering and perspiration
   pulse increasing during exercise
   breathing rate increasing during exercise

3. When you are sick, the body mobilizes its own defenses. Phagocytes are special white blood cells that help to rid the human body of materials which are harmful or foreign. How are these cells an example of homeostasis?

4. Unprepared day-hikers in a mountain region encounter a sudden thunderstorm. They are drenched. After the storm passes, the air temperature has dropped twenty degrees from 60° F to 40° F. One of the group members appears confused, fatiqued, and begins to shiver uncontrollably. These are the first signs of a dangerous condition, known as hypothermia. Here the body temperature drops below 98.6° F due to rapid changes in the temperature of the environment.

   a. What homeostatic mechanisms have failed?

   b. How should the hiker's companions assist him?

   c. How is hypothermia prevented?

APPENDIX C

EQUIPMENT AND MATERIALS

EQUIPMENT AND MATERIALS

INVESTIGATION #1: ORGANISMS

EXPLORATION

Grab Bag

paper sacks
objects such as pieces of sponge, spoons, pine cones, seeds, rocks, plastic fishing worms, balls of clay, cotton balls, caterpillars, fan, tape player

Many Things

objects used in "Grab Bag"
living specimens, such as breeding gerbils or guppies

EXPANSION OF THE IDEA

Cold Water

goldfish
dip net
thermometer
hot plate
several ice cubes
clock
jars or 250 ml. beakers
aquarium water

INVESTIGATION #2: CLASSIFICATION

EXPLORATION

Observing Insects

insect pins
collecting jar
dissecting tray or cardboard box
kill jar*
collecting nets
bug box
hand lens
dissecting scope

*Kill Jar: Small jar and lid; plaster of Paris; ethyl acetate, and blotter paper (filter paper, paper towel).

INVESTIGATION #3: POPULATIONS

EXPLORATION

Organisms at a Study Site

cardboard (20 cm x 20 cm)
string
Optional: thermometers, light meters
nails
meter stick

EXPANSION OF THE IDEA

Habitat Limits

beans or colored popcorn (about 350)
stakes for boundary markers
timer
sandwich bags (75)

Increasing Numbers

fruits (bean pods, tomatoes, apples, or oranges), fruit flies or *Tribolium* beetles

INVESTIGATION #4: PRODUCERS

EXPLORATION

Light and Dark

Swedish ivy or geranium plants
young bean plants
500 ml. beakers
250 ml. beakers
ethyl alcohol (if not available, use methyl alcohol)
Lugol's iodine (potassium iodide)
petri dishes or microscope slides
hot plate
forceps
colored pencils (optional)
gooseneck lamps or intense light source
safety goggles

Variegated Leaves

Coleus or swedish ivy with green and white leaves
(same materials as for Light and Dark)

INVESTIGATION #5: FOOD CHAINS

EXPLORATION

Food Sources

NOTE: These organisms may be the same as those used for "Population Changes" in Investigation #6: Ecosystems

- organisms for a simple, direct food chain (for example, algae-snails-crayfish or algae-water fleas-guppies-crayfish)
- culture dish or aquarium
- microscope
- slides and coverslips
- medicine dropper
- small jar (beaker or baby food jar)

EXPANSION OF THE IDEA

Rotten Food

- spoiled foods showing bacterial and fungal growths such as rotting vegetables, fruits, or cheeses (do not use bloody specimen)
- hand lens or dissecting scopes
- nutrient agar
- petri dishes
- grease pencil
- innoculating loops
- alcohol burners

Optional: Eating for Survival

- magnifying lens and/or bug box
- sweepnet or shake-container (box with clear plastic bag attached)
- guidebook for organisms in your area
- view chamber
- plastic bags
- forceps

INVESTIGATION #6: ECOSYSTEM

EXPLORATION

Population Changes

The setup for this activity should be done at least a week before you plan to begin the investigation.

Microecosystem Setup

- aquarium jar
- minnows or guppies
- water plants
- newts
- *Daphnia*
- snails

Optional

- cover slips
- thermometer
- collecting jar & lid
- dropper
- microscope
- rice, boiled
- hay
- slides
- pond guide

EXPANSION OF THE IDEA

Showdown

Crayfish Setup

- five crayfish
- large plastic container
- crayfish shelters (bricks with holes; flower pots; margarine tubs with holes)

Betta Setup

- water plants
- two male bettas
- plastic or glass container

INVESTIGATION #7: CELLS

EXPLORATION

Plants

- microscope, slides, coverslips
- forceps
- plants: *Coleus*, *Aloe Vera*, lettuce, grasses, mushrooms
- dropper
- razor blades

Animals

- microscope, slides, coverslips
- stain (iodine or methylene blue)
- dropper
- toothpicks

EXPANSION OF THE IDEA

Onion Cells

- microscope, slides, coverslips
- stain (iodine or methylene blue)
- onion
- forceps

Elodea

- microscope, slides, coverslips
- dropper
- *Anacharis (Elodea)*

INVESTIGATION #8: CELL TRANSPORT

EXPLORATION

Cell Membrane Model

- diffusion demonstration: scented aerosol, candle, incense, or ammonia
- dialysis tubing
- Bunsen burner, hot plate, or alcohol burner
- glucose solution
- starch solution
- Benedict's reagent
- Lugol's iodine solution
- string

EXPANSION OF THE IDEA

Osmosis

- Thistle tube or glass tubing
- molasses
- potatoes
- cork borers
- 15% sodium chloride (NaCl) solution
- rubber bands
- ring stands and clamps
- metric rulers
- eyedroppers
- dropper bottles

INVESTIGATION #9: CIRCULATION

EXPANSION OF THE IDEA

Fishtails

- goldfish or guppies
- microscope
- cheesecloth or cotton batting
- Petri dishes

EXPLORATION

Heart Sounds and Exercise

- stethoscope
- timer

Blood Stains

- slides
- blood lancets
- alcohol
- sterile cotton
- Wright's stain
- distilled water
- small bandaids
- centrifuge (optional)

Heart Dissection

- fresh mammalian hearts
- probes, glass or wood rods
- plastic bags for storing
- dissecting trays

INVESTIGATION #10: CALORIES

EXPLORATION

Burning Foods

- foods: marshmallows and nuts
- test tube clamps
- flame source (Bunsen burner or alcohol burners)
- test tubes
- test tube racks
- thermometer
- dissecting needles

Problem: Dieting

- calorie charts

Optional: Testing Foods

- beakers
- test tube clamps
- eyedroppers
- hot plates or Bunsen burners
- brown paper bags (cut in strips)
- 10% sodium hydroxide ($NaOH$) solution
- 0.5% copper sulfate ($CuSO_4$) solution
- egg white, 1:10 dilution
- food samples (may be brought by students)
- test tubes
- test tube racks
- dropper bottles
- Lugol's iodine solution
- Benedict's solution
- 0.5% glucose solution
- 1% starch
- vegetable oil (liquid)

INVESTIGATION #11: DIGESTION

EXPLORATION

Food Tube

- dialysis tubing
- graduated cylinder
- Lugol's iodine solution
- Biuret reagent:
  - 10% sodium hydroxide solution
  - 0.5% copper sulfate solution
- string
- starch solution (boiled)
- Benedict's solution
- hot plate
- beakers
- test tubes

EXPANSION OF THE IDEA

Breakdown of Foods

Stomach juice:
  1M HCl + 2 g. pepsin/100 ml. water
Pancreatic fluid:
  2 g. of commercial pancreatin (the enzyme cleaner for soft contacts is pancreatin; dissolve one tablet in saline solution) and distilled water to make 100 ml. of fluid; add a pinch of sodium carbonate

Protein: boiled eggwhite
Carbohydrate: rice
Fat: vegetable oil
test tubes and stoppers
test tube racks

INVESTIGATION #12: BREATHING

EXPLORATION

Bottled Organisms

- test tubes and stoppers
- Bromthymol Blue solution
- insects (mealworms or crickets)
- cotton balls
- dropper
- Janus Green B

EXPANSION OF THE IDEA

Breathing Machine

- balloons
- two liter plastic cola bottles
- syringes (large) without needles
- sealer (candlewax, clay)
- corks and cork borers
- glass Y-tubes
- tubing
- rubber bands
- straws
- cellophane
- string
- baggies
- cotton

Smoking Machine

- Breathing machine (see above)
- cigarette
- cotton balls

INVESTIGATION #13: RESPONSES

EXPLORATION

Knees and Eyes

- penlight
- reflex hammer
- acetate sheet

Taste

- 5% NaCl solution
- 1% lemon solution
- 5% sucrose solution
- Q-tips

EXPANSION

Balancing Act

- rope, 20′

Eye Tests

- Snellen eye chart
- colored tests
- astigmatism chart

Optional: Eye Dissection

- beef or pork eyes (fresh)
- scissors or scalpels
- dissecting trays
- forceps

INVESTIGATION #14: LOCOMOTION

EXPLORATION

Wings and Arms

- dissecting kit and tray
- boards with eyehooks or rulers
- string
- chicken wings
- "hinge"

EXPANSION

Bone Puzzles

- various cow or horse bones or large animal or human skeletal model

INVESTIGATION #15: CELL DIVISION

EXPLORATION

More Onion Cells

- green onion bulbs and/or prepared *Allium* slides
- slides, coverslips
- stain
- microscope
- scalpel

EXPANSION

Large and Small Cells

- agar
- sodium hydroxide
- metric ruler
- scalpel
- phenolphthalein
- paper towels
- beaker

Planaria

- planaria
- thin paintbrush
- slides
- petri dishes
- microscope or hand lens
- dropper

INVESTIGATION #16: REPRODUCTION

EXPLORATION

Eggs

- Eggs (chicken or frog, fertile and unfertile)
- petri dishes
- dissecting scopes
- incubator
- scissors
- forceps

INVESTIGATION #17: INHERITANCE

EXPANSION

Blood Typing

- sterile blood lancet
- Antigens A and B (Blood Typing Serum)
- toothpicks
- RH factor antigens
- alcohol
- cotton
- slides
- glass marking pencil

INVESTIGATION #18: HOMEOSTASIS

EXPLORATION

Body Thermostats

- oral thermometers
- strip thermometers
- ice and water
- laboratory thermometers
- totetrays or buckets